

1 **DENTAL PROSTHESES MODELING SYSTEM WITH SYMMETRIC**
2 **DOUBLE-WELL TRAYS SLIDABLY MOUNTABLE TO ARTICULATOR**

3 **RELATED APPLICATION INFORMATION**

4 The present application is a continuation-in-part of application Serial No.
5 10/461,968, filed June 12, 2003, which is in turn a continuation-in-part of application Serial No.
6 10/376,325, filed February 26, 2003.

7 **BACKGROUND OF THE INVENTION**

8 A. **Field of the Invention**

9 The present invention relates to articles and methods used in the fabrication of
10 dental prostheses such as crowns and bridges made of various combinations of metal and
11 ceramic materials and used to overlie or replace imperfect or missing teeth. More particularly,
12 the invention relates to a system for use in fabricating crowns and bridges, the system
13 including an apparatus and method for making from a mold or impression of a patient's teeth
14 a dental model cast which is formed from solidified liquid die stone poured into the mold and
15 an upper portion of a tray. The dental model cast is segmentable into die segments, each of
16 which has both horizontally protruding ribs and grooves for releasably engagement with
17 complementary-shaped grooves and ribs formed in a support tray. Individual die segments
18 are optionally fitted with a pin which protrudes downwardly from the die segment, the pin
19 facilitating gripping and manipulating of the die during various fabrication operations performed
20 by a dental technician.

21 B. **Description of Background Art**

22 A dental procedure which is routinely used to restore function and aesthetic
23 appearance to a person's mouth after a tooth has become broken, structurally degraded by
24 disease or removed entirely, consists of capping or replacing the tooth with a prosthetic
25 restoration, such as a crown or bridge. One form of dental prosthesis or artificial tooth
26 replacement which is widely used consists of a cap or crown for a tooth that is made of a resin,
27 molded ceramic material, a precious metal such as gold or an alloy thereof, or a layered
28 combination of metals and resins or

1 ceramic materials. Various combinations of the foregoing materials provide tooth restorations
2 which possess requisite durability and aesthetic appearance, as well as sufficient hardness to
3 be suitable for chewing foods. The process of fabricating tooth restorations has been in use
4 for a substantially long time, and includes a well-defined sequence of steps, which are briefly
5 summarized below.

6 According to a first step in existing methods of fabricating dental prostheses or
7 artificial replacement teeth, a negative impression mold is made of a group of a patient's teeth,
8 including missing, broken or decayed teeth which are to be repaired or replaced and teeth
9 which are laterally adjacent to the defective teeth. Such impressions are typically made by
10 positioning within the mouth of a patient, adjacent to teeth to be restored, a shallow curved tray
11 which contains a polymer material such as alginate, elastomer, hydrocolloid or a polyether,
12 which is capable of being indented by a tooth, and forming and retaining a stable impression
13 of the tooth. The impression material is initially in the form of a putty, slurry or thick paste which
14 rapidly solidifies at ambient room temperature and pressure. The tray is inserted into a
15 patient's mouth positioned generally horizontally and in vertical alignment with a subject area
16 of the teeth, and the patient bites down on the tray, or the tray is pressed into contact with the
17 teeth, thus pressing the teeth into the viscous semi-liquid mold impression material held by the
18 tray. After a few minutes, the mold impression material solidifies into a rubber-like elastomeric
19 state which has formed therein precise negative impressions of teeth in a subject area of the
20 patient's mouth.

21 Dental impression trays for use as described above are available in a variety of
22 styles. One type tray has an arcuately curved plan-view shape which is similar to the curved
23 arrangement of teeth in the jaw. The curved arc length of the tray approximates that of about
24 one half an upper or lower jaw and hence is referred to as a quadrant tray. A flat, paddle-like
25 handle protruding horizontally outwards from one end of the tray is usually provided, to facilitate
26 inserting and removing the tray from a patient's mouth. A typical quadrant tray has on one side
27 thereof a curved trough for receiving impression mold material, may be used to make
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1 impressions of upper or lower jaw quadrants and is referred to as a standard quadrant or
2 single-bite tray.

3 Since an important structural feature of a dental prosthesis is proper registration
4 and biting contact or occlusion between the prosthesis and teeth located in the opposing jaw,
5 it is desirable to make an impression of occluding teeth in the opposing jaw in addition to the
6 impression made of teeth that are to be restored. Therefore, it has been a trend in dentistry
7 for the dental professional to simultaneously make impressions of teeth that are to be restored
8 and occluding teeth in the opposing jaw. A convenient method for simultaneously making
9 restorative and opposing impressions utilizes a tray which has a plan-view shape similar to that
10 of a single-bite, standard quadrant impression tray, but which has upper and lower troughs for
11 holding mold impression material in both upper and lower sides of the tray. Both the upper and
12 lower troughs of these "double-bite" or "triple" trays are filled with viscous impression material
13 and inserted into the patient's mouth between the upper and lower jaws in vertical alignment
14 with teeth to be restored, whereupon the patient bites down on the tray, simultaneously forming
15 impressions of upper and lower teeth.

16 After impressions of teeth have been made in the manner described above, and
17 the mold impression material solidified, the tray holding solidified mold impression material
18 containing negative impressions of a patient's teeth is removed. The mold, typically referred
19 to as an "impression," is then used to make positive replicas of teeth by pouring a semi-liquid
20 molding material such as plaster of Paris, or die stone, into the depressions formed in the
21 impression, which are accurate negative replicas of the teeth. After the die stone has solidified
22 into a hard stone-like casting, or cast, the cast is removed from the impression, a task which
23 is facilitated by the fact that the impression material is elastomeric, enabling it to be readily
24 peeled away from the die. The casting is then used to fabricate one or more tooth restorations
25 or prostheses in the following manner.

26 A master cast, i.e., a cast which includes replicas of teeth which are to be
27 restored, is partitioned into one or more individual segments and/or dies, each consisting of a
28 replica of a tooth which is to be replaced by or fitted with a dental prosthesis. Partitioning of a

1 master cast into die segments is typically accomplished by making parallel vertical saw cuts
2 through the master cast. The individual die segment or segments are then used as three-
3 dimensional models or templates for fabricating crowns or bridges. In general, the exterior
4 surfaces of the prosthesis cannot simply replicate those of the die segments. This is because
5 the occlusal surface of the prosthetic tooth restoration, and to a lesser extent, lateral surfaces
6 of the restoration, may require contouring which is different from that of the die segment. For
7 example, the process of fabricating crowns for diseased or damaged teeth entails grinding
8 decayed or broken outer portions of the tooth down until a stump of healthy dentin or enamel
9 remains, a procedure referred to as "prepping" the tooth. Obviously, a crown which is
10 fabricated to fit onto a stump must have a substantially different, tooth-like shape rather than
11 a stump-like shape.

12 From the foregoing discussion, it can be appreciated that the fabrication of dental
13 prosthesis models from die segments is a labor-intensive task requiring the skills of a
14 prosthodontist or skilled, experienced, dental lab technician. Fabrication of prosthetic dental
15 models typically requires that die segments be contoured by applying a workable material to
16 exterior portions of the die segment, and sculpting the material. The die segment is then
17 replaced into the space in the master cast from which it has been removed, and proper
18 occlusion of the sculpted prosthetic model confirmed by bringing model teeth replicated in the
19 opposing cast into bite-like contacting registration with the occlusal surfaces of the prosthetic
20 model and adjacent teeth replicas of the master cast. This registration check generally must
21 be repeated several times, to ensure proper sculpting of the occlusal surface of the die
22 segment which serves as a model for fabricating a dental prosthesis. Moreover, it is essential
23 that the biting contact or occlusion between the teeth replicated by the master cast and
24 opposing cast precisely duplicate occlusion of the patient's teeth. Therefore, the master cast
25 and opposing cast must be precisely and repetitively pivotably contacted against one another
26 in a motion which simulates the opening and closing of a patient's jaws. Upon satisfactory
27 completion of sculpting of lateral and occlusal surfaces of die segments, the die segment is
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1 used as a mold pattern for casting a metal, ceramic, or metal-ceramic composite dental
2 prosthesis.

3 One type of device which is used to pivotably register master and opposing dental
4 models or arches is referred as an articulator. For example, Cho, U.S. Patent No. 6,019,601,
5 Tray Modeling System With Articulator Assembly And Ejection Mechanism For Producing A
6 Dental Model, discloses a pair of trays which are removably and pivotably joined together by
7 detachable hinge members. Each tray has formed upon an upper surface thereof a
8 rectangularly-shaped, trough-like depression, the longest inner facing side walls of the trough
9 having formed therein alternating vertically disposed ribs and grooves. The device is used by
10 pouring a thick paste of liquid die stone slurry into both a dental impression and the tray, and
11 inverting the impression to enable the liquid die stone slurries in the impression and tray to
12 commingle. When the die stone has solidified, the impression is removed from the cast, and
13 the cast removed from the tray by punching through a frangible base panel in the tray, forcing
14 the cast vertically outwards from the trough. The cast is then sawed into segments, which are
15 returnable to precisely repeatable locations within the trough because of the interlocking ribs
16 and grooves formed in the vertical walls of the cast by die stone solidifying in the grooves and
17 ribs, respectively, of the trough side walls, during hardening of the die stone. In the same
18 manner, an opposing cast is made in the other tray, and the trays pivoted towards one another
19 on the hinge pins to precisely and repeatedly bring the occlusal surfaces of the opposing cast
20 and master cast into occlusal registration.

21 The Cho modeling system and articulator provide a convenient means for
22 preparing and articulating dental models. However, some dental technicians prefer working
23 with die segments which have an elongated cylindrical pin protruding from the base of the die
24 segment. In modeling systems using pinned die segments, the pins are insertably received in
25 holes provided in the base of a tray, and are used to reproducibly position or relate individual
26 die segments to adjacent portions of the master cast. Moreover, a pin protruding from a die
27 segment provides a convenient handle which enables the dental technician to hold a die
28 segment while working on it, including rotating the die segment a full 360 degrees by twisting

1 the die segment pin between the thumb and forefinger of the dental technician. Thus, Sim,
2 U.S. Patent No. 6,402,513, Dental Model Articulator, discloses a dental model articulator which
3 has pinned die segments. The dental model articulator disclosed in Sim utilizes a top insert
4 which has front and rear upwardly protruding ridges that have grooved upper surfaces. The
5 insert is detachably supported on a lower frame. To pour a master cast of a dental impression,
6 a middle frame must be fastened to a lower frame and around the top insert by engaging slots
7 on left and right sides of the middle frame with retentive latches which protrude upwards from
8 the lower frame, on left and right sides of an upper opening in the lower frame which holds the
9 top insert. According to the disclosure of Sim, the middle frame is discarded after completion
10 of a second pour of liquid die stone through a bottom opening of lower frame, to form a
11 perforated matrix for receipt of pins installed in the base of the first impression casting. The
12 grooved insert is discarded after the first pour.

13 In U.S. Patent Application Serial No. 10/376,325, filed February 26, 2003, three
14 of the present inventors disclosed an improved dental modeling system which includes a
15 modeling tray that molds die segment bases which each have short ribs and grooves that
16 enable removal of the die segments from a dental model cast in the tray, and re-insertion of the
17 segments into the tray in precise re-registration with adjacent portions of the cast. That
18 capability is provided by a combination of alignment forces between complementary-shaped
19 grooves and ribs in vertical walls of a shallow trough-like depression in the upper part of a
20 modeling tray, in combination with alignment forces provided by a tapered pin which protrudes
21 downwardly from the die segment and which is received in a pin bore formed in a hardened die
22 stone base matrix cast located in a relatively deep, lower concave opening of the tray. Also,
23 in U.S. Patent application Serial No. 10/461,968, filed June 12, 2003, the aforementioned three
24 inventors disclosed a further improved dental modeling system which employed re-usable
25 modeling trays.

26 Although the above-disclosed systems function admirably in accomplishing their
27 intended purposes, there are occasions in which it would be desirable to provide a dental
28 prostheses modeling system which does not require a second pour of liquid die stone to form

1 a stone base matrix, in addition to the first pour required for molding the dental cast itself, while
2 still enabling die segments to be removed and re-inserted into precise, stable relationship with
3 adjacent portions of a dental impression cast, without requiring that die segments be provided
4 with pins. Also, it would be desirable to provide a dental modeling system in which selected
5 die segments are optionally fitted with a pin which depends downwardly from a die segment,
6 to facilitate manipulation of the segment by a technician during the manufacture of a dental
7 restoration. It would also be desirable to provide a dental modeling system for full arch casts
8 in addition to quadrant casts, with the aforementioned capabilities. Moreover, it would be
9 desirable to provide a means for attaching pairs of full arch casts in an adjustably articulatable
10 fashion to a rugged, dimensionally stable three-dimensional clinical dental articulator of the type
11 used in dental labs, in the usual manner of using molded plaster or other conventional means
12 to attach the casts to upper and lower articulator arms, yet enabling the full arch casts and/or
13 restorations made therefrom to be easily removed from the lab articulator, returned to the
14 dentist, and re-attached to a low cost, disposable display or presentation articulator hinge
15 mechanism for viewing by the dentist and his or her patient. The present invention was
16 conceived of to fulfill the foregoing needs.

17 OBJECTS OF THE INVENTION

18 An object of the present invention is to provide a dental prostheses modeling
19 system for fabricating models of human teeth, in which individual die segments of the models
20 may optionally be provided with a downwardly depending manipulating pin for facilitating
21 handling the die segment in the process of making a dental restoration using the model.

22 Another object of the invention is to provide a dental modeling system which
23 includes a tray having in an upper part thereof an upper well which has an openable base panel
24 or wall for receiving a semi-liquid modeling material or casting material such as plaster of Paris
25 or die stone, the well having relatively high opposed vertical walls, the inner facing surfaces of
26 the walls having formed therein alternating vertically disposed ribs and grooves for forming a
27 dental model casting, a base portion of which casting has in outer walls thereof alternating
28 vertically disposed grooves and ribs shaped complementarily to the ribs and grooves,

1 respectively, in the inner facing tray wall surfaces, interlocking of the casting ribs and grooves
2 with the tray grooves and ribs enabling vertically upward removal of the casting and/or die
3 segment portions thereof from the tray, and vertically downward movement of the casting or
4 die segments thereof into precisely relocatable positions within the tray, the base of the upper
5 well overlying a lower well of sufficient depth to position lower surfaces of pins optionally
6 installed in die segments and protruding perpendicularly downwards therefrom above the lower
7 surface of the tray.

8 Another object of the invention is to provide a dental prostheses modeling system
9 tray in which the openable base wall thereof comprises one or more elongated panels located
10 generally midway between and parallel to upper and lower faces of the tray, the panels being
11 joined by frangible members at outer edges thereof to peripheral base flange walls, whereby
12 the frangible members may be broken to enable a panel to be removed and leave in its place
13 an elongated, panel-shaped aperture through the flange walls, the aperture joining symmetric,
14 approximately equal depth upper and lower wells of the tray.

15 Another object of the invention is to provide a dental prostheses modeling system
16 tray having between lower and upper edge walls thereof an elongated removable panel which
17 serves as a base wall for a trough-shaped pouring well in an upper half of the tray, the panel
18 being provided with an elongated thin rib which protrudes upwardly from an upper surface of
19 the panel, the rib being located generally midway between longitudinally disposed sides of the
20 tray comprising an inner, lingual and an outer, labial side, whereby an elongated longitudinally
21 disposed groove is formed in the base of a dental model cast molded in the tray, the groove
22 serving as a guide or pilot groove for guiding insertion into the cast base of a drill bit used to
23 drill a hole for inserting a manipulating pin centered in a selected portion of the cast which is
24 segmented into a die.

25 Another object of the invention is to provide a re-usable symmetric double-well
26 dental modeling tray which includes a resilient insert member of the proper size and shape to
27 fit resiliently within an aperture which joins upper and lower wells of the tray, the resilient insert
28 member having an upper surface which fits substantially flush with peripheral flange walls which

1 surround the aperture and thereby form therewith a temporary base wall impervious to liquid
2 die stone, the insert being removable from the tray after a dental base cast formed therein has
3 hardened, and the cast removable from the tray to thereby enable re-use of the tray and insert
4 for fabricating other dental model castings.

5 Another object of the invention is to provide knock-out tools and templates for
6 efficiently removing dental castings which have solidified in quadrant and full arch modeling
7 trays.

8 Another object of the invention is to provide an articulator slide receptacle for
9 slidably and releasably receiving and holding in place a full arch dental model cast retained in
10 a modeling tray, the articulator slide receptacle being fixedly securable by plaster of Paris or
11 the like to an upper or lower arm of a three dimensional laboratory or clinical articulator, the tray
12 being slidably removable from the articulator slide to enable a pair of related, full arch dental
13 models to be slidably removed from a pair of slide receptacles detached from the lab
14 articulator, and the trays and models transferred from a dental lab to a dentist's office and re-
15 attached to a lighter duty, presentation/demonstration articulator for viewing by a dentist and/or
16 patient.

17 Various other objects and advantages of the present invention, and its most novel
18 features, will become apparent to those skilled in the art by perusing the accompanying
19 specification, drawings and claims.

20 It is to be understood that although the invention disclosed herein is fully capable
21 of achieving the objects and providing the advantages described, the characteristics of the
22 invention described herein are merely illustrative of the preferred embodiments. Accordingly,
23 we do not intend that the scope of our exclusive rights and privileges in the invention be limited
24 to details of the embodiments described. We do intend that equivalents, adaptations and
25 modifications of the invention reasonably indexable from the description contained herein be
26 included within the scope of the invention as defined by the appended claims.

27 SUMMARY OF THE INVENTION

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1 Briefly stated, the present invention comprehends a dental prostheses modeling
2 system which includes an apparatus and method for fabricating models of human teeth; the
3 models are subsequently used in the fabrication of dental prostheses such as crowns and
4 bridges made of various combinations of metal and ceramic materials and used to overlie or
5 replace imperfect or missing teeth. According to the invention, methods and apparatus are
6 provided for making casts of dental impressions, which are segmentable into die segments for
7 use as models in fabricating individual dental prostheses.

8 According to one aspect of the invention, a modeling or molding tray for molding
9 the base of a quadrant or full arch dental model cast has a longitudinally elongated rectangular
10 or arch-shaped plan view, and has formed in opposed inner vertically disposed longitudinal
11 perimeter walls of a relatively deep well formed in the upper side of the tray, horizontally
12 outwardly protruding protrusions alternating with horizontally inwardly protruding depressions.
13 Complementary-shaped depressions and protrusions are formed in opposed inner facing walls
14 of the base of a dental model cast formed when liquid die stone is poured into the upper well
15 of the tray, and allowed to solidify.

16 According to the invention, the tray includes at least one horizontally disposed,
17 break-away base plate or panel which is located approximately midway between and parallel
18 to upper and lower surfaces of the tray. The break-away base plate is joined at outer peripheral
19 edges thereof by frangible members to flanges which protrude radially inwardly from inner
20 facing surfaces of the vertical well walls, the flanges having upper and lower surfaces generally
21 coplanar with upper and lower surfaces of the break-away panel. The break-away base panel
22 serves as a support base for the lower or base portion of a dental model cast formed by
23 solidification of liquid die stone poured within the well in the upper portion of tray. Semi-liquid
24 die stone is poured to overflowing into a dental impression mold containing imprints of a
25 patient's teeth and also poured to overflowing into the upper opening of the upper well in the
26 upper portion of the tray. The filled impression mold is then inverted, positioned over the tray,
27 and pressed down into semi-liquid die stone in the tray. The liquid die stone in the impression
28 and tray co-mingle and cohere, eventually hardening to form a unitary cast which consists of

1 a lower, base portion molded within the tray and having ribs and grooves molded into opposite
2 vertical walls thereof, and an upper portion which protrudes upwardly from the base and which
3 replicates teeth that imprinted the impression mold.

4 After a dental model cast has hardened in a tray, an upwardly directed force is
5 exerted on the underside of the break-away base plate, breaking the frangible members joining
6 the base plate to the well walls and ejecting the hardened cast upwardly out of the tray. The
7 hardened dental model cast is then segmented by a saw into individual die segments or "dies"
8 which are cast replicas of selected teeth which are to serve as models for fabricating individual
9 dental prostheses. Optionally, individual die segments are individually fitted with a manipulating
10 pin which protrudes downwardly from the base of a die segment and which provides a
11 convenient appendage for a laboratory technician to grasp during the course of fabricating a
12 dental prostheses from a die segment. In this case, the hardened cast die segments are
13 inverted, and blind bores are drilled into the lower surface of individual die segments, the bores
14 being positioned in vertical alignment with cast replicas of selected teeth which are to serve as
15 models for fabricating individual dental prostheses. A cylindrically-shaped manipulating pin is
16 then inserted into each bore and secured in the bore with an adhesive such as glue. The cast
17 is then flipped over to an upright position, with pins protruding perpendicularly downwards from
18 the base of the cast, and reinserted into the upper opening of the tray. Ribs and grooves
19 molded into opposite longitudinally disposed vertical sides of the cast base vertically slidably
20 engage with the relatively long, complementary-shaped grooves and ribs in the inner side walls
21 of the tray which formed the ribs and grooves of the cast. This arrangement ensures that when
22 the cast is reinserted into the tray, the cast is returned to a previously predetermined lateral
23 index position within the tray. Moreover, the cast is relocated at a previously predetermined
24 vertical position within the tray because of abutting contact between the lower surface of the
25 hardened die stone base of the cast and upper surfaces of the base panel flanges.

26 A dental modeling the tray according to the present invention has formed in a
27 lower portion thereof a relatively deep upwardly concave lower cavity or well located below the
28 break-away base panel which has a shape and size similar to and preferably symmetric with

1 that of the upper well in the upper portion of the tray. The lower well is of sufficient depth to
2 position lower surfaces of pins optionally installed in die segments above the lower surface of
3 the tray, and therefore, above a surface used to support the tray. The cast is typically
4 segmented into individual die segments for modeling individual dental prostheses, by making
5 one or more pairs of saw cuts vertically through the cast, adjacent to a selected die segment.
6 Individual die segments are once again reinserted into the upper opening of the tray, to thereby
7 re-assemble a complete cast comprised of individual die segments and adjacent portions of
8 the cast within the tray. Precise placement of die segments within the tray is facilitated by
9 alignment of mating ribs and grooves in the inner sides of the tray and the outer sides of the
10 die segments. The aligning forces provided by insertion of ribs of the casting base into tray
11 grooves enables individual die segments to be quickly and easily removed from the tray,
12 subjected to various prosthesis modeling operations, and returned to a precisely repeatable,
13 indexed positions within the cast, as many times as is required.

14 A preferred embodiment of a dental prostheses modeling system according to the
15 present invention includes an opposing tray for making a casting of a dental impression which
16 was made of teeth opposed to those which are to be fitted with or replaced by prostheses. The
17 preferred embodiment also includes components which hingedly couple a master tray holding
18 a master impression cast to an opposing tray holding an opposing impression cast and forming
19 therewith an articulator mechanism which enables the occlusal surfaces of the master and
20 opposing casts to be brought into pivotable contact with one another, thereby simulating
21 closure of a patient's jaws and proper occlusion of the teeth modeled in the two casts. If dental
22 prostheses are required only for one jaw, the cast made of the opposing jaw does not have to
23 have removable die segments. Therefore, the opposing tray need not be provided with the
24 previously described structural features which enable die segments to be removed and
25 replaced within the tray. However, to minimize the number of different type parts required by
26 the present system, the opposing tray may be constructed identically to the master tray, even
27 though the break-away base panel and indexing grooves and ribs are not required for the
28 opposing cast, since it may remain permanently affixed to the tray.

1 In any event, both the master and opposing trays, which may be of identical
2 construction, are provided with a hinge coupler bracket which extends longitudinally outwards
3 from a short end of each tray. The bracket has the shape of a bifurcated L-bracket including
4 a flat longitudinally disposed horizontal floor plate which extends perpendicularly outwards from
5 a short vertical end wall of the tray. The floor plate of the bracket has a flat horizontally
6 disposed upper surface which is recessed slightly below the upper surface of the perimeter
7 edge wall of the tray. A pair of rectangularly-shaped connector plates protrudes upwardly from
8 an outer longitudinal end portion of the floor plate. The outer connector plates from a pair of
9 trays are releasably joined together by a hinge coupler member that has an upper piano-type
10 hinge, and opposed horizontal upper support plates located on opposite sides of a horizontally
11 disposed hinge pin. The hinge coupler has protruding perpendicularly downwardly from outer
12 ends of each support plate a vertical connector plate which has at the lower end thereof a pair
13 of inwardly facing C-shaped channel members which have therein opposed vertically disposed
14 C-shaped channels adapted to insertably receive an outer upstanding end plate of a tray
15 coupler. This construction enables the outer slotted ends of the hinge coupler to be readily
16 slipped removably over the upstanding connector flange plates of a longitudinally aligned pair
17 of trays, i.e., a master tray and an opposing tray, and thereby hingedly coupling the two trays
18 together so that upper surfaces of the trays which protrude horizontally inwardly from inner
19 vertical wall surfaces of the tray trough, may be pivoted towards and away from one another
20 to simulate closure and opening of a patient's jaws.

21 According to another aspect of the present invention a dental prostheses
22 modeling system utilizes a re-usable modeling or molding tray for fabricating cast dental
23 models. A re-usable molding tray according to the present invention is substantially similar in
24 construction to the molding tray described above, but does not have a break-away center panel
25 located between upper and lower surfaces of the tray. The re-usable molding tray has instead
26 of a break-away center panel a rectangular ring-shaped base wall formed of flanges and has
27 through its thickness dimension a rectangularly-shaped aperture. Thus constructed, the re-
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1 usable tray according to the present invention can be fabricated as an injection molded part,
2 or by removing the break-away center panel from a tray constructed as described above.

3 A dental modeling system with re-usable tray according to the present invention
4 also includes a re-usable resilient insert which has a rectangular plate-shaped base and a
5 rectangular boss lug which protrudes upwardly from the base, the lug being adapted to be
6 resiliently inserted upwardly through the entrance opening to the lower well in the tray into the
7 aperture through the base wall of the tray.

8 The lug has a flat upper surface located at a height above the upper surface of
9 the insert base plate such that when the lower edge wall of the tray is seated on the upper
10 surface of the insert base plate, the upper surface of the lug is parallel to the base plate and
11 is substantially flush with the upper surface of the rectangular ring-shaped base wall of the tray.
12 The lug fits within the tray aperture in a resilient liquid-tight seal, thus forming with adjacent
13 inner side walls of the upper portion of the tray a rectangular box-shaped upper well which
14 serves as a mold for receiving liquid die stone to form the base of a dental model cast. After
15 liquid die stone has hardened to form a cast, the insert is withdrawn from the tray aperture and
16 the lower well in the tray. The tray and cast are then processed by any of the various methods
17 discussed above for the tray provided with a break-away base panel, to fabricate individual,
18 optionally pinned die segments comprising individual dental prostheses models which are
19 repeatedly removable and returnable to precisely pre-determined index positions within
20 remaining portions of a cast held in the tray.

21
22 According to another aspect of the invention, the break-away panel or insert is
23 provided with a thin, longitudinally elongated rib which protrudes upwardly from the upper
24 surface of the break-away panel or insert. The rib is preferably disposed midway between
25 inner, or lingual and outer, or labial sides of the panel or insert, and is disposed longitudinally
26 nearly the full arch length of the tray. Thus, dental model casts made in trays in which the
27 break-away panel or insert which serves as the base of a well or trough for receiving liquid die
28 stone is provided with a rib have formed in the lower surface of the base of the cast a

1 longitudinally disposed groove. The groove protrudes upwardly into the base of a dental model
2 cast from the lower surface of the base, and has a cross sectional shape complementary to that
3 of the rib, e.g., rectangular. Also, the groove formed in the base of a dental model cast is
4 longitudinally elongated, is located generally midway between the inner and outer surfaces of
5 the dental model cast, and extends nearly full length of the cast, i.e., nearly to opposite
6 transverse sides of the cast. Preferably, the rib and groove thickness approximates the
7 diameter of the reduced diameter knurled end of a manipulating pin which is to be inserted into
8 a base portion of a dental model cast severed from the cast to comprise an individual die
9 segment for modeling a dental prosthesis. Thus formed, the groove serves as a pilot or starter
10 indentation for insertably receiving and guiding into the base of a cast the point of a drill bit
11 used to drill a pin bore into a selected die segment portion of the cast. Therefore, pin bores
12 may be easily drilled into the base of a dental model cast at selected longitudinal locations of
13 the cast, without requiring a drilling fixture, by visually aligning the drill bit approximately midway
14 between transversely disposed sides of a die segment, inserting the tip of the bit into the pilot
15 groove, and drilling the pin bore. Pin bores formed using the pilot groove in the foregoing
16 manner are thus centered both laterally and longitudinally with respect to sides of a dental
17 prosthesis die segment.

18 According to another aspect of the present invention, a novel slide receptacle
19 fixture and method for use are provided which enable a pair of related, i.e., upper and lower,
20 full-arch dental models to be affixed to the upper and lower arms of a three-dimensional
21 laboratory articulator with the requisite stability and dimensional placement accuracy required
22 for precision dental lab procedures to be performed in the fabrication of dental restorations,
23 while providing a capability for replaceably removing the full-arch from the dental model
24 laboratory articulator upon completion of dental lab tasks, whereupon the models may be
25 returned to the dentist and re-attached to a less expensive, lighter duty articulator for viewing
26 by a dentist and his or her patient. According to this aspect of the invention, a full-arch dental
27 model does not have to be removed from a modeling tray in which it is formed, or be directly
28 attached by plaster of Paris or the like to upper and lower arms of a laboratory articulator, as

1 is done in the prior art. Instead, according to the present invention, a semi-elliptically-shaped
2 heel-like articulator slide receptacle is provided, the receptacle having a flat base and an
3 upstanding elliptically curved rail or flange wall which has a radially inwardly curved lip or
4 flange that overlies and is parallel to the base plate, and forms therewith an arcuately curved
5 channel which is adapted to receive a similarly-shaped, horizontally disposed abutment flange
6 which protrudes outwardly from the outer curved front vertical surface of a full-arch dental
7 modeling tray according to the present invention. In use, a full-arch dental tray containing a
8 cast dental model is slid forward into the articulator slide receptacle channel, where it is
9 retained in an interference fit. The articulator slide receptacle includes fastening means on the
10 side of its base opposite to that of the rail which enable the receptacle to be securely fastened
11 to an upper or lower laboratory articulator arm. In a preferred embodiment, the fastening
12 means including a disk-shaped pot magnet embedded in a well formed in the lower wall surface
13 of the articulator slide base plate, with the upper surface of the magnet flush with the adjacent
14 base plate wall surface, and a similarly shaped magnet embedded in a cast plaster plate
15 attached to an articulator arm.

16 BRIEF DESCRIPTION OF THE DRAWINGS

17 Figure 1 is an upper plan view of a symmetric double-well quadrant modeling tray
18 for a dental prostheses modeling system according to the present invention.

19 Figure 2 is a side elevation view of a pair of trays of the type shown in Figure 1,
20 the trays being joined by a hinge coupler.

21 Figure 3 is a lower plan view of the trays and coupler of Figure 2.

22 Figure 3A is an upper plan view of the hinge coupler of Figure 3.

23 Figure 3B is a lower plan view of the hinge coupler of Figure 3.

24 Figure 4 is a perspective view showing a first step of a method for making a
25 modeling cast or "arch" from a single quadrant impression mold made of a group of a patient's
26 teeth located in either an upper or lower jaw and including one or more teeth to be renovated.

27 Figure 5 is a perspective view of the arrangement of Figure 4 showing a second
28 step in making a dental model cast from a single quadrant impression.

1 Figure 6 is a perspective view showing a third step of making a dental model cast
2 in which a completed master dental model casting residing in a first tray in which it was cast,
3 an opposing cast positioned above the master cast with occlusal surfaces of upper and lower
4 replica teeth in the opposing and master casts temporarily adhered together in proper occlusal
5 registration by blobs of wax, and the first, master tray coupled to a second, opposing tray by
6 a hinge coupler.

7 Figure 7 is a view similar to that of Figure 6, but showing a fourth step in which
8 semi-liquid die stone is applied to both the upper surface of the opposing cast, and the upper
9 surface of the opposing tray.

10 Figure 8 is a view similar to that of Figure 7, but showing a fifth step in which the
11 opposing tray pivoted on the axis of the hinge coupler to thereby bring the semi-liquid die stone
12 material in the opposing tray and the upper surface of the opposing casting into contact to
13 thereby co-mingle and cohere upon hardening, thus securing the opposing cast to the opposing
14 tray.

15 Figure 9 is a perspective view showing a first step in a method of making a master
16 dental model cast and an opposing cast from master and opposing impression molds made of
17 teeth in opposite jaws of a patient by a double-bite or "triple" impression tray.

18 Figure 10 is a perspective view of a second step in fabricating master and
19 opposing articulated casts according to the present invention.

20 Figure 11 is a perspective view of a third step in the method of Figure 10.

21 Figure 12 is a perspective view of a fourth step of the double-tray method of
22 Figure 10, as well as that the single tray method of Figures 4-8.

23 Figure 13 is a perspective view of an optional step in the double tray method of
24 Figure 10, as well as the single tray method of Figures 4-8, in which manipulating pins are
25 installed in a dental model cast.

26 Figure 14A is partly broken away elevation view showing a pinned quadrant cast
27 installed in a double-well quadrant modeling tray according to the present invention.

1 Figure 15 is a perspective view of a final step in the double tray method of Figure
2 10, as well as the single tray method of Figures 4-8, in which individual die segments are
3 severed from a dental model cast.

4 Figure 16 is a perspective view of a completed articulatable model of a pair of
5 master and opposing dental modeling system casts fabricated using the method and apparatus
6 according to the present invention.

7 Figure 17 is a fragmentary view of the dental cast of Figure 14 on an enlarged
8 scale, showing a die segment thereof.

9 Figure 18 is another fragmentary view of the article of Figure 11 on an enlarged
10 scale, showing part of a master cast with the die segment of Figure 17 removed from the cast.

11 Figure 19 is a perspective view of a knock-out template for removing a break-
12 away base panel of the tray shown in Figures 1-3.

13 Figure 20A is a side elevation view of a knock-out tool useable with the template
14 of Figure 18 to remove a break-away base panel from the tray of Figures 1-3.

15 Figure 20B is a side perspective view of the tool of Figure 20A.

16 Figure 21 is a perspective view of a sawing stand for use in segmenting a dental
17 model cast according to a method of the present invention.

18 Figure 22 is a perspective view of a drilling alignment fixture comprising a
19 component for use in an alternative embodiment of a pin tray dental prostheses modeling
20 system according to the present invention.

21 Figure 23 is a perspective view of an alternative method for removing a break-
22 away base panel from a tray comprising a component of the apparatus according to the present
23 invention, without simultaneous ejection of a dental model cast from the tray, as shown in
24 Figure 12.

25 Figure 24 is a perspective view showing the tray of Figure 23, with the break-away
26 base panel removed and slidably supported on the drilling alignment fixture of Figure 21.

1 Figure 25 is a perspective view showing how the drilling jig of Figures 22 and 23
2 is used to guide drilling of pin bores into the base of the dental model cast shown in Figures 23
3 and 24.

4 Figure 26 illustrates one method for installing die segment pins in pin bores
5 formed in the dental model cast as shown in Figure 25.

6 Figure 27 illustrates one method for segmenting the dental model cast of Figures
7 25-26 into individual die segments.

8 Figure 28 is an upper plan view of a re-usable quadrant modeling tray for a pin
9 tray dental prostheses modeling system according to the present invention.

10 Figure 29 is a lower plan view of the modeling tray of Figure 27.

11 Figure 30 is an upper plan view of a tray insert for use with the tray of Figures 28
12 and 29.

13 Figure 31 is a front elevation view of the insert of Figure 30, the rear elevation
14 view being identical to the front elevation view.

15 Figure 32 is a right side elevation view of the insert of Figure 31, the left side
16 elevation view being identical to the right side elevation view.

17 Figure 33 is an upper plan view of the tray of Figure 28, showing the insert of
18 Figures 30-32 installed in the tray of Figures 28-29.

19 Figure 34 is a front elevation view of the tray and installed insert of Figure 32.

20 Figure 35 is a front perspective view showing a method of removing the insert
21 from the tray of Figure 34.

22 Figure 36 is an upper plan view of a full-arch tray for a dental prostheses
23 modeling system according to the present invention.

24 Figure 36A is a radially inwardly directed vertical sectional view of a full-arch tray
25 of Figure 36, taken in the direction of curved line 36A-36A.

26 Figure 36B is a curved, radially outwardly directed vertical sectional view of the
27 full-arch tray of Figure 36, taken in the direction of curved line 36B-36B.

28

1 Figure 37 is a side elevation view of a pair of trays of the type shown in Figure 36,
2 the trays being joined by a hinge coupler.

3 Figure 38 is a lower plan view of the trays and coupler of Figure 37.

4 Figure 39 is a perspective view showing completed master and opposing dental
5 casts formed in the trays of Figures 37 and 38, and showing the trays and casts pivoted on the
6 hinge coupler to comprise an articulated, full-mouth dental model.

7 Figure 40A is an upper plan view of an anvil template for use in removing a full-
8 arch dental model cast from the tray of Figure 36.

9 Figure 40B is a lower plan view of a knock-out tool for use with the anvil template
10 of Figure 40A in removing a full-arch dental model cast from the tray of Figure 36.

11 Figure 41 is a perspective view showing the manner of using the anvil template
12 and knock-out tool of Figures 40A and 40B to eject a full-arch cast dental model from the tray
13 of Figures 36.

14 Figure 42A is a right side perspective view showing a full-arch sawing fixture.

15 Figure 42B is a rear perspective view of the full-arch sawing fixture of Figure 42A.

16 Figure 43 is a perspective view showing the full-arch sawing fixture of Figures 42A
17 and 42B being used to partition individual die segments from a full-arch dental model casting.

18
19 Figures 44A, 44B, 44C are lower plan views of a drilling alignment fixture for full-
20 arch dental model casts according to the present invention, showing an index arm of the fixture
21 at three different orbital locations.

22 Figure 45 is an upper plan-view of the drilling alignment fixture of Figure 44.

23 Figure 46 is a front elevation view of the drilling alignment fixture of Figure 44.

24 Figure 47 is a rear elevation view of the drilling alignment fixture of Figure 44.

25 Figure 48 is a vertical sectional view of the drilling alignment fixture of Figure 46,
26 taken in the direction of line 48-48.

1 Figure 49 is a right side perspective view showing the drilling alignment fixture of
2 Figure 46 in use to facilitate drilling a pin bore into the base of a die segment of a full-arch
3 dental model cast.

4 Figures 50A-50L illustrate a prior art 3-D laboratory or clinical dental articulator,
5 and a prior art method of attaching full-arch dental model casts to an articulator, in which:

6 Figure 50A shows a pair of full-arch dental models casts in a prior art trays and
7 temporarily adhered together by wax in proper occlusion.

8 Figure 50B is an upper perspective view of a 3-D articulator mechanism and
9 plastic mounting plate adapted to be fastened to the upper or lower surface, respectively, of
10 a support base lower arm or upper arm of the articulator mechanism.

11 Figure 50C is a lower plan view of the plastic mounting plate of Figure 50B.

12 Figure 50D is an upper plan view of the plastic mounting plate of Figure 50C.

13 Figure 50E is a lower perspective view of the plastic mounting plate of Figure
14 50D, showing semi-liquid die stone adhered to the upper surface of the mounting plate.

15 Figure 50F is a lower perspective view of the full-arch dental model of Figure 50A,
16 showing a ferromagnetic or magnetized disk being affixed to a lower surface of a prior art
17 molding tray holding a lower full-arch dental model.

18 Figure 50G is a view similar to that of Figure 50F, showing a pot magnet
19 magnetically attached to the lower surface of the magnetic disk of Figure 50F.

20 Figure 50H is a view similar to that of Figure 50G, showing a silicone pin-
21 protection dam being adhered to a lower surface of the molding tray.

22 Figure 50J is a view showing the mounting base plate of Figures 50C and 50D
23 attached by screw to the lower arch support arm of a 3-D articulator, the lower arch of Figure
24 50H having had semi-liquid die stone smeared onto the lower surface of the lower arch support
25 tray, pressed into the semi-liquid die stone on the upper surface of the plastic mounting base
26 plate, and allowed to harden.

27 Figure 50K is a perspective view showing semi-liquid die stone applied to the
28 upper surface of the upper arch support tray and to the lower surface of an upper mounting

1 plate secured to an upper pivotable arm of the articulator preparatory to pivoting the arm
2 downwardly to press the two semi-liquid, die-stone coated surfaces together to cohere and
3 harden.

4 Figure 50L is a perspective view showing a finished pair of upper and lower full-
5 arch dental model casts properly occluded and removably attached to upper and lower arms
6 of the 3-D articulator.

7 Figure 51 is a reverse or lower plan view of an articulator slide receptacle
8 according to the present invention.

9 Figure 52 is a rear end elevation view of the receptacle of Figure 51.

10 Figure 53 is an obverse or upper plan view of the receptacle of Figure 52.

11 Figures 53B is a vertical sectional view of the receptacle of Figure 53, taken in
12 the direction of line 53B-53B.

13 Figure 54A is a perspective view showing a pair of upper and lower full-arch trays
14 holding a pair of upper and lower dental model castings and the manner of installing the trays
15 on a pair of the receptacles of Figures 51-53.

16 Figure 54B shows the receptacle-mounted trays of Figure 54A joined in an
17 occlusal relationship by the hinge coupler of Figure 3A.

18 Figure 55 is a perspective view of a first step in a method according to the present
19 invention of attaching an articulator slide receptacle holding a lower full-arch tray and dental
20 model cast of Figure 54, to the lower arm of a 3-D articulator.

21 Figure 56 is a lower perspective view showing a second step for attaching the
22 lower slide receptacle of Figure 55 to the lower articulator arm.

23 Figure 57 is a lower perspective view showing a third step in attaching the lower
24 slide receptacle to the lower articulator arm.

25 Figure 58A is a perspective view showing the lower slide receptacle of Figure 57,
26 which has had a magnet magnetically attached to a magnetic disk in the center of the lower
27 surface of the lower slide receptacle smeared with liquid die stone and pressed into liquid die
28

1 stone smeared onto the upper surface of a first plastic mounting plate shown in Figure 55, and
2 allowed to harden.

3 Figure 58B is a perspective view showing the upper slide receptacle of Figure
4 58A, to which a pot magnet has been magnetically attached, preparatory to applying semi-
5 liquid die stone applied to the upper surface of the slide, and to the lower obverse surface of
6 a second plastic mounting plate attached to the upper pivotable articulator arm preparatory to
7 pivoting the arm downwardly to press the semi-liquid die-stone coated surfaces together to
8 cohere and harden.

9 Figure 59 is a perspective view showing a finished pair of upper and lower full-
10 arch dental model casts contained in a pair of trays mounted in a pair of slide receptacles
11 magnetically attached to upper and lower arms of the 3-D articulator.

12 Figure 60 is a perspective view showing full-arch dental model casts, trays and
13 slide receptacles removed from the articulator of Figure 59.

14 Figure 61 is a view showing a pair of full-arch dental model casts contained in
15 trays removed from the slide receptacles of Figure 60 and joined together by a hinge
16 mechanism for viewing approximate occlusal relationship, by a dentist and patient, yet
17 returnable to a precisely re-locatable occlusal relationship in the 3-D articulator by re-inserting
18 the trays into slide receptacles and magnetically adhering the slide receptacles to arms of the
19 3-D articulator.

20 Figure 62 is an upper perspective view of an insert for use with a tray of the type
21 shown in Figure 36, modified by removal of break-away panels from the tray.

22 Figure 63 is a lower plan view of the insert of Figure 62 and tray of Figure 36,
23 showing a method of installing and removing the insert in a lower well portion of the tray.

24 Figure 64 is a lower plan view of the tray and installed insert of Figure 63.

25 Figure 65 is an upper plan view of the tray and insert of Figure 64.

26 Figure 66 is an upper perspective view of a modification of the quadrant modeling
27 tray shown in Figures 1-3, which has a ribbed break-away panel.

1 Figure 67 is a lower plan view of the tray of Figure 66, showing a break-away
2 panel thereof removed after pouring a dental model cast in the upper well of the tray, a groove
3 formed in the lower surface of the cast by a rib protruding upwardly from the break-away panel,
4 saw cuts made in the cast to sever a die segment from the cast, a pin bore drilled into the base
5 of the segment using the groove as a pilot for a drill bit, and a manipulating pin installed in the
6 pin bore.

7 Figure 68 is an upper plan view of a modification of the quadrant modeling
tray insert shown in Figures 30-32, which is provided with a pilot groove-forming rib.

8 Figure 69 is a front elevation view of the modified insert of Figure 68.

9 Figure 70 is a right side elevation view of the insert of Figure 69, the left side
10 elevation view being identical to the right side elevation view.

11 Figure 71 is an upper perspective view of a modification of the full-arch dental
12 modeling tray of Figure 36, which has ribbed break-away panels.

13 Figure 72 is a lower plan view of the tray of Figure 68 showing a break-away
14 panel thereof removed after pouring a dental model cast in the upper well of the tray, a groove
15 formed in the lower surface of the cast by a rib protruding upwardly from the break-away panel,
16 saw cuts made in the cast to sever a die segment from the cast, a pin bore drilled into the base
17 of the segment using the groove as a pilot for a drill bit, and a manipulating pin installed in the
18 pin bore.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A. Drawing Description Summary

19 Figures 1-3 and 19-21 illustrate components of a basic embodiment of dental
20 prostheses modeling system with symmetric double well quadrant modeling trays according to
21 the present invention, while Figure 22 illustrates a drilling alignment fixture for use in an
22 alternate embodiment of the system.

23 Figures 4-8 illustrate steps in a method of making a dental model cast from a
24 single quadrant impression for use in fabricating dental prostheses, according to a basic
25 embodiment of the invention.
26
27
28

1 Figures 9-11 illustrate preliminary steps in making master and opposing dental
2 model casts from master and opposing mold impressions made by teeth in upper and lower
3 jaws of a patient, use a "double-bite" or "triple" impression tray.

4 Figures 12-15 illustrate further steps in the method of fabricating a dental
5 prostheses model according to the present invention, from either a single-bite or double-bite
6 impression.

7 Figures 16-18 illustrate a finished pair of dental prostheses model casts mounted
8 in an articulator according to the present invention.

9 Figures 19-21 illustrate tools for use in practicing the present invention.

10 Figures 22-27 illustrate an alternative apparatus and method for making dental
11 model casts according to the present invention.

12 Figures 28-35 illustrate the construction and use of a re-usable symmetric double-
13 well modeling tray and insert according to the present invention.

14 Figures 36-39 illustrate components of a full-arch symmetric double-well dental
15 modeling prostheses tray according to the present invention.

16 Figures 40-41 illustrate the structure and use of a full-arch anvil template and
17 knock-out for removing a full-arch dental model cast from the modeling tray shown in Figures
18 36-39.

19 Figures 42 and 43 illustrate the structure and function of a full-arch sawing fixture
20 according to the present invention.

21 Figures 44-49 illustrate the structure and function of a full-arch drilling fixture
22 according to the present invention.

23 Figure 50 illustrates a prior art method of attaching full-arch dental model casts
24 to a laboratory dental articulator.

25 Figures 51-61 illustrate the structure and function of a full-arch articulator slide
26 receptacle according to the present invention.

27 Figures 62-65 illustrate the construction and use of a re-usable full-arch modeling
28 tray and insert apparatus to the present invention.

Figures 66-72 illustrate modifications of the tray and insert of Figures 1-3, and 30-32, respectively, which are provided with a groove forming rib.

B. Detailed Description

Referring now to Figures 1-3, an apparatus 30 for making dental prostheses quadrant models according to the present invention may be seen to include a pair of quadrant symmetric double-well molding trays 31A, 31B which are releasably connectable by a hinge mechanism 32 and used for fabricating and holding dental models made according to the present invention. As shown in Figure 16 and as will be described in detail below, hinge mechanism 32 enables trays 31A, 31B to be pivoted between a mutually co-planar horizontally disposition as shown in Figure 2, to a configuration in which one of the molding trays overlies the other in a generally parallel disposition, as shown in Figures 2 and 16.

As will be made clear in the ensuing description, only one of the quadrant molding trays 31A, 31B need be provided with certain novel structural features according to the present invention, if a removable dental model cast is to be made of teeth in a single jaw of a patient. However, according to a preferred method of practicing the invention, trays 31A and 31B may be identical, and for the sake of brevity in the ensuing description, the letter suffix A or B is deleted unless necessary to distinguish between two trays, e.g., a tray in which a master dental cast is molded versus a tray in which an opposing cast is molded.

As shown in Figures 1-3, each quadrant tray 31 has a longitudinally elongated generally rectangular plan view shape. Tray 31 preferably has flat and parallel upper and lower surfaces 33, 34, respectively. Also, tray 31 has longitudinally elongated, rectangularly shaped, generally vertically disposed front and rear side walls 35, 36, a rectangularly shaped inner (hinge side), vertical end wall 37 and an outer vertically disposed end wall 38.

As shown in Figure 1, quadrant tray 31 includes a thin rectangular plate-shaped base partition or base wall panel 42, which is located within the tray, disposed parallel to and approximately equidistant from upper and lower surfaces 33, 34 of the tray, thus partitioning the interior of the tray into generally symmetrical upper and lower parts. Base or partition wall 42 forms with adjacent vertical inner walls in an upper part of tray 31, a relatively deep

1 | rectangularly-shaped upper depression or upper well 39, and in a lower part of the tray a lower
2 | well 63 shaped symmetrically to the upper well. Upper and lower wells 39, 63 are concentric
3 | with the outer vertically disposed perimeter wall surface 40 of tray 31, and are nearly as large
4 | as the outer perimeter of the tray. Thus arranged a thin rectangularly-shaped ring comprised
5 | of upper and lower peripheral ring portions 41U, 41L having a thickness of about 1/8 inch is
6 | formed between upper and lower wells 39, 63 and outer vertical perimeter wall surface 40 of
7 | tray 31. Peripheral rings 41U, 41L have disposed perpendicularly outwards from base wall 42,
8 | i.e., upwardly and downwardly, respectively, an inner peripheral wall surface 43 which includes
9 | front longitudinally disposed inner surfaces 45U, 45L, rear longitudinally disposed inner
10 | surfaces 46U, 46L, and shorter transverse end surfaces, i.e., a left transverse inner surface 47,
11 | and a right transverse inner surface 48.

12 | As shown in Figure 2, upper and lower wells 39 and 63 have approximately equal,
13 | depths which are relatively large with respect to their cross-section area dimensions, i.e., about
14 | 9/32 inch for a well about 2-1/4 inch long by about 3/4 inch wide. The reasons that both wells
15 | are relatively deep will become clear from the ensuing description.

16 | Referring again to Figure 1, longer front and rear inner wall surfaces 45, 46 of an
17 | upper portion 41U of peripheral ring 41 have formed therein a plurality of vertically disposed
18 | ribs 49 which protrude inwardly towards a longitudinal center line of upper well 39. Ribs 49
19 | protrude vertically upwardly of base wall 42, and form between each adjacent pair of ribs a
20 | vertically disposed notch or groove 50. As will be described in detail below, alternating ribs and
21 | grooves 49, 50 form complementary grooves and ribs in outer vertical surfaces of the base of
22 | a dental model cast which is formed in upper well 39 by solidified liquid die stone poured into
23 | the upper well, thus enabling the base of a cast and individual segments severed from the
24 | base, to be removably returned to exact pre-existing locations within tray 31, because of the
25 | indexing action of the ribs and grooves being insertably received within complementary-shaped
26 | grooves and ribs molded into the sides of the model cast from hardened liquid die stone. As
27 | shown in Figure 3, lower portions of front and rear wall surfaces 45, 46 of a lower portion 41L
28 |

1 of ring 41 adjacent to lower well 63 are optionally provided with ribs and grooves 49B, 50B
2 which may be extensions of ribs and grooves 49, 50.

3 Referring now to Figures 1, 2, and 3, it may be seen that tray 31 is provided with
4 front and back or rear abutment flanges 55F, 55B, which protrude outwardly from front and rear
5 walls 35, 36, respectively, of tray 31. As shown in the figures, each abutment flange 55F, 55B
6 has the shape of a horizontally disposed, thin, longitudinally elongated rectangular rib or web
7 which has an outer vertical wall surface 56 that is spaced outwards from an outer front or rear
8 wall of tray 31, and flat and parallel, horizontally disposed, upper and lower surfaces 57, 58,
9 respectively. The function of front and rear abutment flanges 55F, 55B are described below.

10 Referring now to Figures 1 and 3, it may be seen that base wall 42 of upper well
11 39 in molding tray 31 has a flat upper surface 59, and includes an outer rectangular ring-
12 shaped peripheral portion 60 formed of flanges which protrude perpendicularly inwards from
13 the inner wall surfaces of the front, rear, inner and outer end walls of the tray. Base wall 42
14 also includes a concentrically located, longitudinally elongated rectangularly-shaped center
15 knock-out or break-away panel 61. Base wall 42 has a thickness of less than the height of tray
16 31, e.g., about 1/16 inch for a tray height of about 5/8 inch, and upper surface 59 of base wall
17 42 is located about 9/32 inch below upper peripheral edge wall 33 of the tray. Thus arranged,
18 base wall 42 forms within upper and lower portions of tray 31 relatively deep, e.g., about 9/32
19 inch, symmetrically shaped upper and lower wells 39 and 63, respectively, which protrude
20 inwardly from upper peripheral face 59 and lower peripheral face 64 of the tray, respectively.

21
22 Referring still to Figures 1 and 3, it may be seen that center break-away panel 61
23 of tray base wall 42 is connected to outer rectangular ring-shaped portion 60 of the base wall
24 by a plurality of readily breakable, or frangible members 65. Thus, as shown in Figure 3, outer
25 vertical wall surface 66 of base wall break-away center panel 61 is joined to an inner vertical
26 wall surface 67 of ring-shaped portion 60 of the base wall by a plurality of thin, breakable pins
27 65, e.g., a pair of front and rear pins and a pair of left and right pins. In a preferred
28 embodiment, a tray 31 is fabricated as a unitary molded plastic part, with outer surface 66 of

1 break-away center panel 61 angled downwardly and inwardly away from adjacent inner wall
2 surface 67 of ring-shaped outer portion 60 of base wall 42. With this construction, pins 65 may
3 be readily molded to have a thickness substantially less than that of break-away center panel
4 61, thus enabling the pins to be readily broken and thereby permitting the center panel to be
5 broken away and removed from tray 31. With break-away center panel 61 thus removed from
6 tray 31, base wall 42 of the tray has through its thickness dimension a concentrically located,
7 longitudinally elongated rectangular-shaped aperture 69, as shown in Figure 23.

8 As shown in Figure 3, center break-away panel 61 of tray base wall 42 preferably
9 is provided with one or more bosses 70 which protrude perpendicularly downwards from the
10 lower surface 71 of the base wall. Although the exact shape and size of bosses 70 is not
11 critical, the embodiment of tray 31 shown in Figure 3 has three square cross-section bosses
12 70 which each have a flat lower surface 72 and a blind circular bore 73 which extends
13 perpendicularly upwards from the lower surface. The three bosses 70 include a longitudinally
14 centrally located center boss 70C, and left (inner) and right (outer) bosses 70L, 70R spaced
15 equal longitudinal distances away from the center boss. The function and purpose of bosses
16 70 is described below.

17 Referring to Figures 1, 2 and 3, it may be seen that each tray 31 has protruding
18 horizontally outwards from a short end wall 37 thereof a hinge coupler bracket 74 for releasable
19 attachment to hinge mechanism 32. Each hinge coupler bracket 74 has a shape approximating
20 that of an L-bracket, an upright leg of which is bifurcated into two spaced apart, parallel plates.
21 Thus, as shown in Figures 1-3, hinge coupler bracket 74 includes a rectangularly-shaped base
22 plate 75 which protrudes outwardly from end wall 37 of tray 31. Base plate 75 has horizontally
23 disposed upper and lower surfaces 76, 77 which are parallel to upper surface 33 of tray 31.
24 Upper surface 76 of bracket base plate 75 is preferably recessed below upper surface 33 of
25 the perimeter edge wall of tray 31, and has protruding perpendicularly upwards therefrom a
26 first, outer rectangularly-shaped upright leg plate 78. Outer upright leg plate 78 has an outer
27 vertical surface 79 which is co-planar with outer vertical edge wall 80 of a base plate 75.

1 Bracket 74 includes a second, inner upright leg plate 81 which is shaped similarly
2 to outer leg plate 78, and which protrudes perpendicularly upwards from base plate 75 at a
3 location spaced longitudinally inwardly from the outer upright leg plate. Inner upright leg plate
4 81 has an outer vertical wall surface 82 which is spaced longitudinally inwards of and parallel
5 to an inner vertical wall surface 83 of outer leg plate 78. Preferably, a rectangularly-shaped
6 aperture 84 is formed through base plate 75 of bracket 74, between outer and inner upright leg
7 plates 78, 81. The purpose of aperture 84 is to facilitate elastic flexure of the outer and inner
8 leg plates away from and towards one another, thereby facilitating elastic gripping engagement
9 of hinge mechanism 32, as will be described below.

10 Referring still to Figures 2, 3A, 3B, 6, and 7, it may be seen that hinge mechanism
11 32 of apparatus 30 includes a pair of rectangular plan-view hinge members 85, 86, each having
12 a thin upper rectangularly-shaped plate 87, 88, respectively. Plate 87 has a pair of spaced apart,
13 coaxially tubular extensions 89, 90, which protrude upwardly from an inner end of the plate,
14 parallel thereto. Plate 88 has a single, centrally located tubular extension 91 which fits coaxially
15 between tubular extensions 89, 90 of plate 87, and is hingedly joined thereto by an elongated
16 cylindrical hinge pin 91A which is disposed rotatably through bores (not shown) of the tubular
17 extensions. The other parts of hinge members 85, 86 are identical, and include a larger
18 rectangularly-shaped coupler plate 92 which depends perpendicularly downwardly from outer
19 edge 93 of each upper plate. Coupler plate 92 has at opposite sides of a lower horizontal edge
20 wall 94 thereof a pair of vertically disposed, L-shaped guide members 95 which form
21 therebetween a pair of vertically disposed C-shaped channels 95A which are adapted to
22 vertically upwardly insertably receive an inner upright leg plate 81 of a tray 31.

23 Each hinge member 85, 86 also has protruding laterally inwardly from the L-
24 shaped guide member 95 a vertically disposed lug member 96. Each lug member 96 has an
25 inner vertical edge wall 97 which is located parallel to and laterally spaced apart from an inner
26 vertical edge wall 98 of coupler plate 92. As shown in Figure 2, inner facing edge walls 97 of
27 lug members 96 abut to limit inward pivotable motion of the coupler plates to a parallel position.
28 As shown in Figure 3B, inner vertical edge wall 98 of each coupler plate 91 preferably has

1 formed therein a plurality of parallel, horizontally disposed, triangular cross-section ribs 100
2 which alternate with grooves 101 to form a washboard-like surface 102. The thickness of hinge
3 coupler plate 92, measured between the vertices of triangular webs 100 and outer surface 102
4 of the coupler plate, is slightly greater than the spacing between an inner and outer faces 83,
5 82 of outer and inner leg plate uprights 78, 81 of hinge coupler bracket 74 of tray 31. Thus,
6 when coupler plate 92 is inverted downwardly into the space 104 between the tray upright leg
7 plates, the latter flex elastically slightly apart, and ribs 100 bite into the plates slightly, thus
8 frictionally engaging the coupler plate with the tray legs. A description of certain components
9 of a pin tray dental prostheses modeling system according to the present invention having been
10 given, the manner of using those components according to methods of the present invention
11 is presented below.

12 Figure 4 illustrates a first step in making a dental prostheses model cast or "arch"
13 from a single quadrant impression mold made of a group of a patient's teeth located in a left
14 or right half of an upper or lower jaw of the patient. As shown in Figure 4, upper well 39 in the
15 upper portion of a first molding tray 31A is filled with a semi-liquid die stone material such as
16 plaster of Paris, to a level slightly above upper peripheral wall 33 of the tray. As is also shown
17 in Figure 4, a dental impression mold A containing imprints B of a patient's teeth is also filled
18 to overflowing with liquid die stone. In a second step of making a dental model, filled
19 impression A is then inverted, positioned over tray 31A, and pressed down onto the semi-liquid
20 die stone in the tray, as shown in Figure 5. The semi-liquid die stone in impression A thus co-
21 mingles with that in tray 31A. Time is then allowed for the liquid die stone in tray 31A to harden
22 into a stone-like cast. Next, impression mold A is peeled upwardly and off from the hardened
23 die stone in tray 31, leaving therein a cast C which is an accurate replica of teeth which
24 impressed or imprinted the impression mold, as shown in Figure 6.

25 Then, in a third step, as shown in Figure 6, a cast D made of an impression taken
26 of teeth opposing those which are to be restored and which imprinted impression A is
27 positioned above first, master cast C, which replicates teeth for which prostheses are to be
28 fabricated. Opposing cast D is positioned in proper occlusal contact with master cast C, and

1 temporarily secured in that configuration by blobs of wax E, for example, as shown in Figure
2 6. Next, in a fourth step, as shown in Figure 7, a second, opposed tray 31-B, coupled by hing
3 mechanism 32 to tray 31-A containing master dental model cast C, is filled to overflowing with
4 liquid die stone L, as is upper surface of opposing cast D. Then, in a fifth step, as shown in
5 Figure 8, the upper surface 33B of opposing tray 31-B is pivoted towards contact with upper
6 surface F of opposing cast D, causing die stone in the upper impression to co-mingle with that
7 in the opposing tray. Time is once again allowed for the liquid die stone in opposing tray 31-B
8 and opposing cast D to harden. Wax blobs E are then heated slightly to melt the wax, enabling
9 opposing tray 31-B, now secured to opposing cast D by solidified die stone, to be pivoted away
10 from master cast C. Further processing steps used to complete pinned dental model cast C
11 are described below, following a description of preliminary steps for making master and
12 opposing casts from a double-bite, or triple tray impression; the final steps of making finished
13 casts are the same for both single quadrant and triple tray impression casts.

14 Figures 9-11 illustrate a method of making dental model casts from double-bite
15 or triple-tray impressions according to the present invention.

16 Figure 9 shows a first step in making a dental prostheses model cast from a
17 double-bite or triple-tray impression mold G made from a patient's teeth located in lower or
18 upper jaw and including teeth which are to be replaced by or fitted with one or more prosthetic
19 restorations or replacements, and occluding teeth in an opposing jaw. As shown in Figure 9,
20 upper well 39 in the upper portion of a first molding tray 31- α is filled with a semi-liquid,
21 hardenable modeling substance such as plaster of Paris or die stone, to a level slightly above
22 upper peripheral wall surface 33 of the tray. As is also shown in Figure 9, a concave
23 depression in a first, master side H of two-sided dental impression G imprinted with teeth which
24 are to be restored, is also filled to overflowing with liquid die stone. The filled master side
25 impression H is then inverted, positioned over tray 31- α , and pressed down into the semi-liquid
26 die stone in the tray, as shown in Figure 10. The semi-liquid die stone in the impression H thus
27 co-mingles with semi-liquid die stone material in tray 31- α . Time is then allowed for the liquid
28 die stone in tray 31- α and master impression H to harden into a stone-like master cast J. Next,

1 liquid die stone L is poured to overflowing into a second, opposing tray 31- β , which is pivotably
2 connected to first tray 31- α by a hinge mechanism 32.

3 As shown in Figure 11, a concave depression in a second, opposing side K of
4 two-sided impression mold G imprinted with teeth in a jaw opposed to the jaw containing teeth
5 to be restored, is filled to overflowing with liquid die stone L. As is also shown in Figure 11,
6 opposing tray 31- β is then pivoted towards contact with the upper surface of semi-liquid die
7 stone in concave impression area K of the opposing impression, causing die stone in the upper,
8 opposing impression to co-mingle with die stone in the upper, opposing tray. Time is once
9 again allowed for the semi-liquid die stone in opposing tray 31- β and opposing impression K
10 to harden into a stone-like opposing cast L. Next, a master dental model cast J formed in
11 master tray 31- α is temporarily and replaceably removed from the tray, in the following manner.

12 A preferred method for removing master dental model cast J from tray 31- α
13 consists essentially of exerting an upwardly directed force on break-away center panel 61 of
14 base wall 42 of the tray which is of sufficient strength to break pins 65 which join the center
15 panel to peripheral ring panel 60 of the base wall, and then pushing upwardly on that portion
16 of the lower surface M of a cast J that is accessible through aperture 69 through the base wall.
17 According to a preferred method of removing cast J from tray 31- α , a template 190 and tool
18 191, shown in Figures 19, 20A and 20B, are employed.

19 As shown in Figure 19, template 190 includes a flat base 192 having a
20 longitudinally elongated, rectangular shape. Base 192 of template 190 has protruding
21 perpendicularly upwards from a flat upper surface 193 thereof a longitudinally elongated,
22 rectangularly shaped lug 194 which has a vertically disposed peripheral wall surface 195 that
23 is located concentrically with respect to the outer peripheral wall surface 196 of the base, and
24 has a flat upper surface 197 disposed parallel to upper surface 193 of base 192. Template 190
25 also includes at opposite short ends 198, 199 thereof a pair of opposed, vertically disposed
26 guide structures 200, 201 which have formed therein a pair of opposed inner facing C-shaped
27 guide spaces 202, 203 which together form an open rectangular-shaped tray receipt space 204
28 which is concentric with outer peripheral wall surface 195 of lug 194. As shown in Figures 12

1 and 19, tray receipt space 204 has a rectangular plan view shape which is similar to that of tray
2 31, but of larger size so that the tray may be loosely inserted downwardly into the space, the
3 bottom surfaces 72 of bosses 70 of base wall 41 abutting upper surface 197 of lug 194.

4 As shown in Figures 20A and 20B, a knock-out tool 191 according to the present
5 invention includes a rectangular block-shaped body 205 which has vertically elongated,
6 rectangularly-shaped parallel left and right side walls 206L, 206R and vertically elongated,
7 rectangularly-shaped parallel front and back side walls 207F, 207B, which are perpendicular
8 to the side walls. Body 205 has disposed perpendicularly through left and right side walls 206L,
9 206R thereof an arch-shaped tunnel 208. Body 205 of tool 191 has a flat, horizontally disposed
10 upper end wall 209, and a flat lower wall surface 210. Tunnel 208 penetrates lower wall
11 surface 210, thus defining between front and back side walls 207F, 207B a pair of front and
12 rear legs 211F, 211B which have opposed lower, inner vertical wall surfaces 212F, 212B which
13 border the tunnel. Legs 211F, 211B each has at a lower end thereof a laterally disposed
14 rectangularly shaped foot flange 213F, 213B which has a flat lower surface coextensive with
15 lower wall surface 210 of body 205, and flat, parallel upper surfaces 214F, 214B. Foot flanges
16 213F, 213B protrude horizontally a short distance inwards into tunnel 208, and have vertically
17 disposed, inner facing parallel end walls 215F, 215B. Foot flange front and back end walls
18 215F, 215B are spaced apart at a distance slightly greater than the space between the outer
19 surface of front and peripheral upper edge walls of tray 31.

20 Figure 12 illustrates the use of template 190 and knock-out tool 191 to remove
21 a dental cast J from tray 31- α . As shown in Figure 12, tray 31- α containing cast J is placed in
22 opening 204 of template 190, with bottom surfaces 72 of bosses 70 supported on upper
23 surface 197 of lug 194. Knock-out tool 191 is then positioned above front and back abutment
24 flanges 55F, 55B of tray 31 with lower surfaces of front and back knock-out tool flanges 213F,
25 213B contacting the upper surfaces of the abutment flanges of the tray. A sharp blow is then
26 delivered downwardly to the upper surface of the knock-out tool which causes the knock-out
27 tool flanges to exert a downward force on the tray abutment flanges, thus causing lug 197 to
28 exert an upwardly directed force on break-away center panel 61 of tray base wall 42, thereby

1 breaking pins 65 which join the center panel to rectangular ring-shaped portion 60 of the base
2 wall, and thereby ejecting cast J upwardly and out from the tray.

3 Dental prostheses models fabricated utilizing the novel method and modeling tray
4 described above may optionally be fitted with pins to facilitate manipulating the models during
5 the course of manufacturing finished dental restorations. Thus, as shown in Figure 13, a fifth,
6 optional step in making a dental prostheses model according to the present invention consists
7 of drilling blind pin bores P into the base M of an inverted cast J, at locations aligned with
8 portions of the cast which are to be severed from adjacent portions of the cast, to thereby form
9 die segments which are to be used as models for dental prostheses. Pin bores P are also
10 drilled into locations of the base corresponding to portions of the cast adjacent to die segments.

11
12 After pin bores P have been drilled into cast J as described above, cylindrical
13 metal pins 120 are inserted into the base. As shown in Figure 13, each pin has a short knurled
14 end 121 and a longer smooth shank 122. Pin bores P are drilled to a depth approximating the
15 length of knurled end 121 of pin 120, so that the smooth shank 122 protrudes perpendicularly
16 downwards from lower face N of individual die segments U severed from the cast J as will be
17 described below. Pins 120 are preferably secured in pin bores P by coating knurled ends 121
18 of each pin with adhesive before inserting a pin into a bore.

19 Figure 14 shows a dental model cast J fitted with pins 120 in the manner
20 described above and installed in a tray 31. As shown in Figure 14, lower well 63 of tray 31 is
21 sufficiently deep to position lower surfaces 123 of the pins above lower wall surface 64 of the
22 tray, and thus above a supporting surface Z on which the tray may be placed.

23 Figure 15 illustrates a method of severing individual die segments from a cast L.
24 Thus, as shown in Figure 15, base M of pinned cast L is placed upright in a longitudinally
25 disposed horizontal channel 126 formed in the upper surface of a longitudinally elongated,
26 rectangular block-shaped sawing stand fixture 127 of the type shown in Figure 21. A saw S is
27 then used to make a pair of vertical cuts T through cast J, on each side of a portion of the cast
28 which is to be used as die segment U for use as a dental prostheses model. As shown in

1 Figure 21, a pair of transversely spaced apart and aligned front and rear grooves or cutouts
2 129F, 129B are cut downwardly from upper edges of front and rear walls 128F, 128B of fixture
3 127, the grooves providing clearance for saws. After one or more die segments U have been
4 severed from dental model cast J, the die segments and adjacent portions of the cast may be
5 repeatedly re-installed in tray 31 at precisely indexed locations, owing to the interlocking action
6 of ribs and grooves of the cast engaging complementary grooves and ribs in the inner side
7 walls of tray 31. Figures 16, 17, and 18 show a completed articulateable model of a master
8 cast J with replaceable die segments, and an opposing cast fabricated by the above described
9 apparatus and method according to the present invention.

10 Figures 23-27 illustrate a modification of the apparatus and method of the present
11 invention described above. The modified apparatus and method employ the first three steps
12 described above for both single quadrant and double-bite impression models. However, as
13 shown in Figure 23, a fourth step in the modified method comprises removing frangible center
14 panel 61 of base wall 42 of tray 31 by grasping a center panel boss 70 between the jaws V of
15 a pliers W, and exerting a pulling force sufficient to break center panel support pins 65. Blind
16 pin bores P are then drilled into the base M of a cast J, in a manner described below, using a
17 drilling alignment fixture 130 of the type shown in Figure 22.

18 As shown in Figure 22, drilling alignment fixture 130 includes an elongated,
19 generally rectangular-shaped body 131 which has a flat lower surface 132, and a flat upper
20 surface 133 in which is formed an elongated, shallow rectangular-shaped channel 134 which
21 is adapted to receive a tray 31 containing therein the base M of a cast J.

22 Located in front and back sides of channel 134 are coplanar, horizontally
23 disposed flat front and back ledges 135F, 135B which are of a proper spacing to support front
24 and rear abutment flanges 55F and 55B of a tray 31.

25 Drilling alignment fixture 130 also includes a circular drill guide bushing 136 fitted
26 through a lower wall 137 of the fixture. An index line 138 is inscribed on the outer surfaces of
27 the fixture, in longitudinal alignment with the center line of a coaxial bushing 136.

1 As shown in Figures 24 and 25, drilling alignment fixture 130 is used by
2 longitudinally sliding a cast J supported on ledges 135F, 135B of the fixture to thereby position
3 a location of the cast where it is desired to insert a pin in longitudinal alignment with bushing
4 bore index line 138. Drilling alignment fixture 130 and cast J are then rotated together as a unit
5 to expose the lower surface 139 of the fixture, whereupon a drill bit is inserted through bore 140
6 of bushing 136, and rotated to drill a pin bore P at a desired location into the base M of cast J.
7 Next, as shown in Figure 26, pins 120 are inserted into and secured in pin bores P made as
8 described above.

9 As shown in Figure 27, tray 31 containing cast J, is re-oriented to an upright
10 position, and vertical saw cuts T are made into the cast to sever die segments from adjacent
11 portions of the cast. Saw cuts T are made downwards just to the upper surface levels of front
12 and back abutment flanges 55F, 55B. Cutting to the common level of the upper surface of the
13 abutment flanges ensures that the saw cuts are made completely through the thickness of base
14 M of cast J, thus enabling a pinned die segment U to be removed from tray 31, as shown in
15 Figure 18, and re-inserted into a precisely predetermined position relative to adjacent segments
16 of the cast, which need not be removed, and repeatedly removed and re-inserted.

17 According to a first variation of the modified apparatus and method described
18 above and illustrated in Figures 23-27, after pin bores P have been drilled into the base M of
19 a cast J as shown in Figure 25, the cast may be ejected from a tray 31, as for example, using
20 a template 90 and knock-out tool as shown in Figure 4. Then, pins 120 may be installed in the
21 pin bores P of cast J in the manner indicated in Figure 13, and the remaining steps of the basic
22 embodiment of the method shown in Figures 13 through 15 and described above performed
23 to produce a completed dental prostheses model. According to a second, slightly different
24 variation of the modified apparatus and method depicted in Figures 23-27, pins 120 may be
25 installed in bores P of cast J prior to ejecting the cast J from a tray 31, whereupon the steps of
26 the basic embodiment depicted in Figures 16-18 and described above performed to produce
27 a complete dental prostheses model.

1 Figures 28 and 29 illustrate a re-usable modeling tray 231 for a pin-tray dental
2 prostheses modeling system according to the present invention. Re-usable modeling tray 231
3 is substantially identical in structure and function to tray 31 described above, but does not have
4 a break-away center panel 61 or frangible support members 65 therefor. Instead, as shown
5 in Figures 28 and 29, molding tray 231 has a base plate or wall 242 which consists of a
6 rectangular ring-shaped peripheral portion 260 that circumscribes a concentrically located
7 rectangular-shaped aperture 269. Thus constructed, tray 231 can be fabricated as an injection
8 molded plastic part, or by modifying a new or used tray 31 by removing a break-away center
9 panel 61 from base wall 42 of the tray 31 by the method described above.

10 Figures 30-32 illustrate an insert 300 for use with modeling tray 231 according to
11 the present invention. As shown in Figures 30-32, insert 300 has a flat, longitudinally elongated,
12 rectangular plan-view base plate 301. As shown in Figures 31 and 32, base plate 301 of insert
13 300 has a generally uniform thickness, and has flat and parallel lower and upper surfaces 302,
14 303, respectively. Referring to Figures 30-32, insert 300 may be seen to include a
15 longitudinally elongated, rectangular plan view boss 304 which protrudes upwards from upper
16 surface 303 of insert base plate, the boss being concentrically located with respect to front,
17 rear, left and right perimeter wall surfaces 305, 306, 307 and 308, respectively, of the base
18 plate 301. As shown in Figures 30 and 31, boss 304 of insert 300 has generally vertically
19 disposed left and right side walls 309, 310, and front and rear side walls 311, 312, which are
20 inclined towards a vertical, longitudinally disposed mid plane of the boss. As shown in Figures
21 31 and 32, boss 304 has protruding upwardly from an upper surface 313 of a trapezoidally
22 transverse cross section base 314 thereof a longitudinally elongated rectangularly-shaped lug
23 315.

24 Lug 315 has front and rear longitudinally elongated, generally vertically disposed
25 edge walls 316, 317 which protrude upwardly from front and rear angled boss walls 311, 312,
26 respectively, of boss 304. Also, lug 315 has generally vertically disposed left and right side
27 walls 318, 319, which protrude upwardly from upper surface 313 of boss base 314, and has a
28 flat upper surface 322 parallel to base plate 301 of the insert. As shown in Figures 30 and 31,

1 left and right side walls 318, 319 of lug 315 are recessed short equal distances from left and
2 right sides 309, 310, respectively of base 314 of boss 304.

3 Referring to Figures 30 and 31, it may be seen that front and rear side walls 311,
4 312 of boss 304 of insert 300 optionally have formed in short, more generally vertically
5 disposed lower portions thereof a plurality of alternating ribs 320 and grooves 321 which are
6 adapted to mesh conformally with optional complementarily-shaped grooves 250B and ribs
7 249B, respectively, in lower well 263 of tray 231.

8 Referring now to Figures 33 and 34, it may be seen that insert 300, constructed
9 as described above, is adapted to be fitted into lower well 263 of tray 231, with lug 315 fitting
10 conformally within aperture 269 through base wall 242 of the tray. Thus positioned, upper
11 surface 322 of insert lug 315 is substantially flush with upper surface 259 of base wall 242 of
12 tray 231.

13 In a preferred embodiment, tray insert 300 is made of a resilient material, e.g.,
14 an elastomeric polymer such as polyurethane. This choice of materials enables lug 315 to fit
15 resiliently within aperture 269 through base wall 242 of tray 231 in a liquid tight seal therewith.
16 Liquid die stone may then be poured into upper well 239 of tray 231 to form the base of a
17 dental model cast, in the manner shown in Figures 4 and 11 and described above. After liquid
18 die stone has hardened to form a cast, insert 300 is readily withdrawn from lower well 263 of
19 tray 231, by grasping an edge of base plate 301 and exerting a downwardly directed parting
20 force relative to the tray, as for example, by grasping an edge of the tray and an edge of the
21 insert base plate between a thumb and forefinger and exerting a pinching force thereon, as
22 shown in Figure 35. Following removal of insert 300 from tray 231, a dental prostheses may
23 be fabricated according to the steps shown in Figures 24-27 and described above, or according
24 to the first or second variations described, which are also described above.

25 Figures 36-38 illustrate full arch double-well modeling trays 431 according to the
26 present invention. Modeling trays 431 are intended for use in making full-mouth, or full-arch
27 upper and lower dental models of a patient's upper and lower jaws. The structure and function
28 of modeling trays 431 are substantially analogous to those of quadrant double-well modeling

1 tray 31 described above. The main difference between the quadrant and full-arch trays is that
2 the quadrant tray has upper and lower wells which have in plan view the shape of an elongated
3 rectangular box of constant width, while the full-arch tray has symmetric upper and lower wells
4 which have in plan view the shape of an elongated, semi-elliptical arch-shaped strip of constant
5 width. In the quadrant tray, the rectangular upper and lower wells are disposed between front
6 and rear longitudinal walls, and shorter left and right transversely disposed walls. On the other
7 hand, the elliptically arc-shaped upper and lower wells of the full-arch tray 431 are disposed
8 between radially spaced apart, outer and inner parallel elliptically curved vertical walls, which
9 both terminate at a transversely disposed diametrical wall that lies on the minor axis of an
10 ellipse.

11 As shown in Figures 36-38, each tray 431 has in plan view the shape of a semi-
12 ellipse, similar to that of a shoe heel. Tray 431 preferably has flat and parallel upper and lower
13 surfaces 433, 434, respectively. Also, tray 431 has arcuately curved, elliptically arc-shaped,
14 parallel, generally vertically disposed outer and inner walls 435, 436. Walls 435, 436 are
15 spaced radially apart from one another at a constant radial distance, and perpendicularly
16 intersect a straight, transversely disposed posterior end wall 437. Posterior end wall 437 is
17 disposed transversely along a line corresponding to a minor axis of semi-elliptically-shaped tray
18 431, and has in a posterior elevation view a transversely elongated rectangular shape.

19 As shown in Figure 36, full-arch tray 431 includes a thin, arcuately curved base
20 plate or base wall panel 442 which is disposed parallel to and approximately equidistant from
21 upper and lower surfaces 433, 434 of the tray. Base panel 442 has the shape of a semi-
22 elliptically curved strip of constant width, and forms with the inner surfaces of adjacent vertical
23 perimeter walls of the tray, in the upper part thereof, a relatively deep upper depression or well
24 439 which has in upper plan view the shape of semi-elliptical band or strip of constant radial
25 width. As shown in Figure 38, base plate 443 of tray 431 also forms in lower portion a lower
26 well 463 which has a shape symmetric to that of upper well 439.

27 Upper and lower wells 439, 463 have inner and outer wall surfaces 439I, 439O,
28 463I, 463O, respectively, which are parallel to the outer vertically disposed perimeter wall

1 surface 440 of the tray, and form therewith a thin arcuately-shaped upper and lower peripheral
2 rings 441U, 441L, respectively, between the upper and lower wells 439, 463 and the outer
3 vertical wall surface of tray 431. Peripheral rings 441U, 441L have disposed perpendicularly
4 outwards from base wall 442 inner, generally vertically disposed, peripheral wall surfaces 443U,
5 443L which include anterior front, arcuately curved portions 445U, 445L, posterior rear,
6 arcuately curved upper and lower vertical portions 446U, 446L, and posterior, straight vertical
7 wall surfaces 448U, 448L.

8 As may be understood by referring to Figure 37, upper and lower wells 439, 463
9 have approximately equal, relatively great depths, related to their cross-sectional area
10 dimensions, i.e., about 9/32 inch deep for a well having an arc length of about 5 inches and a
11 radial width of about 5/8 inch.

12 Referring again to Figure 36, front and rear inner wall surfaces 445U, 446U of
13 upper peripheral ring 441U have formed therein a plurality of vertically disposed ribs 449 which
14 protrude radially inwardly towards a longitudinal center line of upper well 439. Ribs 449
15 protrude vertically upwardly of base wall 442, and form between each adjacent pair of ribs a
16 vertically disposed notch or groove 450. As may be seen best by referring to Figures 36A, 36B,
17 ribs and grooves 449, 450, respectively, have in elevation view the shape of narrow, vertically
18 disposed upright and inverted triangular, or wedge-shaped plates, respectively. As will be
19 described in detail below, alternating ribs and grooves 449, 450 form complementary grooves
20 and ribs in outer vertical surfaces of the base of a dental model cast which is formed in upper
21 well 439 by solidified liquid die stone poured into the upper well, thus enabling the base and
22 individual segments cut from the base, to be removably returned to exact pre-existing locations
23 within tray 431, because of the indexing action of the ribs and grooves being insertably received
24 within complementary-shaped grooves and ribs molded into the sides of the model cast by
25 hardened liquid die stone. Moreover, since downwardly pointing wedge-shaped ribs are
26 molded into the base of a dental model cast formed in tray 431, which have the shape of
27 grooves 450 in the inner wall surfaces of the tray, when the dental model cast or die segments
28 severed therefrom are re-inserted vertically downwardly into the tray, the wedge-shaped ribs

1 protruding from the base or die segments wedge frictionally into the wedge-shaped grooves
2 450 between ribs 449 of the tray walls. That wedging action helps to secure individual die
3 segments within tray 431 and prevent die segments from falling out when the tray is inverted.

4
5 Referring to Figures 36-38, it may be seen that tray 431 is provided with a semi-
6 elliptically curved anterior abutment flange 455F, and a transversely disposed, straight posterior
7 abutment flange 455B, which protrude outwardly from anterior and posterior walls 435, 436,
8 respectively, of tray 431. As shown in the figures, each abutment flange 455F, 455B has the
9 shape of a horizontally disposed, thin, longitudinally elongated rectangular cross-section rib or
10 web which has an outer vertical wall surface 456 that is spaced outwards from an outer anterior
11 or posterior wall of tray 431, and flat and parallel, horizontally disposed, upper and lower
12 surfaces 456U, 456L, respectively. Anterior and posterior abutment flanges 455F, 455B
13 together form a unitary abutment flange 458 which encircles and is parallel to the outer vertical
14 wall surfaces of tray 431. The function of anterior and posterior abutment flanges 455F, 455B
15 are described below.

16 Referring to Figures 36 and 38, it may be seen that base wall 442 of upper well
17 439 in molding tray 431 has a flat upper surface 459, and includes an outer rectangular ring-
18 shaped peripheral portion 60 formed of flanges which protrude perpendicularly inwards from
19 the inner wall surfaces 445U, 446 of peripheral ring 441U of the of the tray. Base wall 442 also
20 includes a pair of concentrically located, arcuately-shaped, arcuately spaced apart center
21 knock-out or break-away panels 461L, 461R. Base wall 442 has a thickness of less than the
22 height of tray 431, e.g., about 1/16 inch for a tray height of about 5/8 inch, and upper surface
23 459 of base wall 442 is located about 9/32 inch below upper peripheral edge wall 433 of the
24 tray. Thus arranged, base wall 442 forms within upper and lower portions of tray 431 relatively
25 deep, e.g., about 9/32 inch, symmetrically shaped upper and lower wells 439 and 463,
26 respectively, which protrude inwardly from upper peripheral face 433 and lower peripheral face
27 464 of the tray, respectively, towards base wall 442.

1 As shown in Figures 36 and 38, it may be seen that center break-away panels
2 461 of tray base wall 442 are connected to outer rectangular ring-shaped portion 460 of the
3 base wall by a plurality of readily breakable, or frangible members 465. Thus, as shown in
4 Figure 38, outer vertical wall surfaces 466 of base wall break-away center panels 461 are
5 joined to inner vertical wall surfaces 467 of ring-shaped portions 460 of the base wall by a
6 plurality of thin, breakable pins 465, e.g., a pair of anterior and posterior pins for each panel
7 461R, 461L. In a preferred embodiment, tray 431 is fabricated as a unitary molded plastic part,
8 with outer surface 466 of break-away center panels 461 angled downwardly and inwardly away
9 from adjacent inner wall surfaces 467 of ring-shaped outer portions 460 of base wall 442. With
10 this construction, pins 465 may be readily molded to have a thickness substantially less than
11 that of break-away center panels 461, thus enabling the pins to be readily broken and thereby
12 permitting the center panels to be readily broken away and removed from tray 431. With break-
13 away center panels 461 thus removed from tray 431, base wall 442 of the tray has through its
14 thickness dimension a pair of arcuately elongated, constant width aperture 469R, 469L. The
15 apertures have shapes approximating that of a pair of quadrant sectors of an ellipse which are
16 disposed arcuately forward from posterior transverse end wall 437, and have longitudinally
17 disposed front end walls which are spaced circumferentially apart on opposite sides of a thin
18 web 469C.

19 As shown in Figure 38, center break-away panels 461 of tray base wall 442
20 preferably are provided with one or more bosses 470 which protrude perpendicularly
21 downwards from the lower surface 471 of each panel. Although the exact shape and size of
22 bosses 470 is not critical, each panel 461 of the embodiment of tray 431 shown in Figure 38
23 has protruding downwardly therefrom three square cross-section bosses 470 which each have
24 a flat lower surface 472 and a blind circular bore 473 which extends perpendicularly upwards
25 from the lower surface. The three bosses 470 include a longitudinally centrally located center
26 boss 470C, and front and rear bosses 470F, 470R spaced equal longitudinal distances away
27 from the center boss. The function and purpose of bosses 470 is described below.

Referring to Figures 36-38, it may be seen that each tray 431 has protruding horizontally outwards from posterior transverse end wall 437 thereof a hinge coupler bracket 474 for releasable attachment to hinge mechanism 342. Each hinge coupler bracket 474 has a shape approximating that of an L-bracket, an upright leg of which is bifurcated into two spaced apart, parallel plates. Thus, as shown in Figures 36-38, hinge coupler bracket 474 includes a rectangularly-shaped base plate 475 which protrudes outwardly from end wall 437 of tray 431. Base plate 475 has horizontally disposed upper and lower surfaces 476, 477 which are parallel to upper surface 433 of tray 431. Upper surface 476 of bracket base plate 475 is preferably recessed below upper surface 433 of the perimeter edge wall of tray 431, and has protruding perpendicularly upwards therefrom a first, outer rectangularly-shaped upright leg plate 478. Outer upright leg plate 478 has an outer vertical surface 479 which is co-planar with outer vertical edge wall 480 of a base plate 475.

Bracket 474 includes a second, inner upright leg plate 481 which is shaped similarly to outer leg plate 478, and which protrudes perpendicularly upwards from base plate 475 at a location spaced longitudinally inwardly from the outer upright leg plate. Inner upright leg plate 481 has an outer vertical wall surface 482 which is spaced longitudinally inwards of and parallel to an inner vertical wall surface 483 of outer leg plate 478. Preferably, a rectangularly-shaped aperture 484 is formed through base plate 475 of bracket 474, between outer and inner upright leg plates 478, 481. The purpose of aperture 484 is to facilitate elastic flexure of the outer and inner leg plates away from and towards one another, thereby facilitating elastic gripping engagement of hinge mechanism 432, has been described above for use of hinge mechanism 32 with quadrant trays 31.

A pair of full arch dental modeling trays 431A, 431B is used to make master and opposing full-arch dental models of teeth in a patient's upper and lower jaws, in a method exactly analogous to that employed to make master and opposing quadrant models using a pair of trays 31A and 31B. That method is depicted in Figures 4-8 and described in detail above, and therefore is not repeated here. Figure 39 shows completed full-arch master and opposing dental model casts made using a pair of trays 431A, 431B as shown in Figures 36-38, by the

1 method described above, and shows the casts fastened to pivotable hinge coupler 32 to
2 comprise an articulated full-mouth dental model.

3 A preferred method for removing a master full-arch dental model cast JF from a
4 tray 431A consists essentially of exerting upwardly directed forces on break-away center panels
5 461 of base wall 442 of the tray which are of sufficient strength to break pins 65 which join the
6 center panels to peripheral ring 460 of the base wall, and then pushing upwardly on that portion
7 of the lower surface MF of a cast JF that is accessible through apertures 469 through the base
8 wall. According to a preferred method of removing cast JF from tray 431A, an anvil template
9 490 and knock-out tool 491, as shown in Figures 40 and 41, are employed.

10 As shown in Figures 40 and 41, template 490 includes a flat base 492 which has
11 an outline shape similar to the plan view shape of a tray 431, but of a larger size. Thus, base
12 492 of template 490 has in plan view the shape of a semi-ellipse, similar to that of a shoe heel
13 and that of tray 431, but having a semi-major and semi-minor axes each about 3/4 inch larger
14 than those of the semi-elliptically-shaped perimeter of abutment flange walls 455F, 455B of the
15 tray. Base 492 of template 490 has protruding upwardly from a flat upper surface 493 thereof
16 a semi-elliptically curved peripheral flange wall 494 which has a vertically disposed outer wall
17 surface 495 coextensive with the outer perimeter wall surface of the template, and an inner wall
18 surface 496 which is parallel to the outer wall surface and spaced radially inwardly thereof by
19 about 3/8 inch. Peripheral flange wall 494 has a flat upper surface 497 and includes an
20 arcuately curved anterior portion 498 and a straight, transversely disposed posterior end portion
21 499 which coincides with a minor axis of the semi-elliptically shaped base. Posterior end
22 portion 499 of peripheral flange wall 494 has formed therein a centrally located, rectangularly-
23 shaped notch 500 which protrudes downwardly from upper surface 497 of the flange wall, the
24 notch terminating at upper surface 493 of the template base. As shown in Figure 41, notch 500
25 provides clearance for a hinge coupler arm bracket 474 which protrudes rearwardly from a full-
26 arch tray 431.

27 As shown in Figure 40, flange wall 494 of full-arch knock-out template 490 also
28 is provided with one or more notches which are spaced circumferentially apart from hinge

1 coupler notch 500, to provide convenient access for receiving a person's thumb or finger to
2 facilitate grasping and removing a tray 431 seated on template 490 as shown in Figure 41.
3 Thus, as shown in Figure 40, upper surface 497 of flange wall 494 has protruding downwardly
4 therefrom three rectangular cross-section notches, including an anterior notch 501 centered
5 on a major axis of the elliptical template base, and a pair of notches 502A, 502B spaced
6 equidistant from either side of the anterior notch. Preferably, notches 501, 502A and 502B
7 terminate at lower ends thereof in flat surfaces 503, 504A and 504B which are co-planar,
8 parallel to, and spaced above upper surface 493 of template base 492.

9 As shown in Figure 40, base 492 of full-arch knock-out template is provided with
10 a pair of arcuately curved, rectangular cross-section ribs 505A, 505B which are spaced
11 transversely apart equidistant from a longitudinal center line of the base coincident with its
12 major axis, and which protrude perpendicularly upwards from upper surface 493 of the base.
13 The outer vertical surfaces 506A, 506B of ribs 505A, 505B are parallel to inner wall surfaces
14 507A, 507B of flange wall 494, and form therebetween a semi-elliptically curved, sector-shaped
15 channel 507C of a generally constant radial width which is slightly larger than radial span
16 distance between outer surfaces of outer and inner semi-elliptically curved walls 435, 436 of
17 tray 431.

18 As shown in Figure 41, template base 492 has a semi-elliptically shaped recess
19 508 of the proper size and shape to vertically insertably receive in a conformal loose fit the
20 lower peripheral flange wall 441L which protrudes downwardly from centrally located abutment
21 flange 455 of a full-arch tray 431. Moreover, ribs 505A, 505B protruding upwardly from upper
22 surface 403 of template base 492 are of an appropriate height and location to abut the lower
23 surfaces of break-away center panels 461, or bosses which protrude downwardly from panels
24 which are so constructed, when a tray 431 is placed conformally within the recess 508 in the
25 upper portion of template base 492.

26 Referring again to Figures 40 and 41, it may be seen that full-arch knock-out tool
27 491 has a tabular upper portion 509 which has a heel-like planar shape similar to that of knock-
28 out template 490, and four downwardly depending generally square cross-section legs,

1 including a centrally located anterior leg 510, a centrally located posterior leg 511, and a pair
2 of posterior corner legs 512A, 512B transversely aligned with the central posterior leg.

3 Figure 41 illustrates the manner of using full-arch anvil template 490 and full-arch
4 knock-out tool 491 to remove a full-arch dental model cast JF from tray 431. As shown in
5 Figure 41, tray 431 containing cast JF is placed in recess 508 in the upper surface of template
6 base 492, with bottom surfaces 372 of the break-away base panels 461A, 461B of the tray, or
7 the bottom surfaces of optional bosses 370 protruding downwardly from break-away base
8 panels 461A, 461B of the tray, supported on upper surfaces 513A, 513B of ribs 505A, 505B.
9 Knock-out tool 491 is then positioned above tray 431, with the lower surface 514 of anterior tool
10 leg 510 resting on the upper surface of the vertex of anterior flange 455, the lower surfaces
11 515A, 515B of posterior corner legs 512A, 512B contacting upper surfaces of opposite sides
12 of anterior flange 455, and the lower surface 516 of central posterior tool leg 511 contacting the
13 upper surface of a semi-elliptically shaped web section 517 of the tray 431 which is located
14 between inner facing wall surfaces of the tray and which has upper and lower surfaces 521,
15 522, which are co-planar with upper and lower surfaces of the abutment flanges, respectively.
16 A sharp blow is then delivered to the flat upper surface 523 of knock-out tool 491, causing the
17 knock-out tool legs to exert downwardly directed forces on tray abutment flange 455 and rear
18 web 517. This force in turn causes the upper surfaces of ribs 505A, 505B to exert upwardly
19 directed forces on break-away center panels 461A, 461B of tray base wall 442, thereby
20 breaking pins 465 which join the center panels to rectangular ring-shaped portion 460 of the
21 base wall, and thence ejecting cast JF upwardly and out from the tray.

22 Figures 42 and 43 illustrate the structure and function of a full-arch sawing fixture
23 520 according to the present invention. As shown in Figure 42, full-arch sawing fixture 520
24 includes a flat base 522 which has in plan view an outline shape and size similar to those of
25 a tray 431. Thus, base 522 of sawing fixture 520 has in plan view the shape of a semi-
26 elliptically shaped plate similar to that of a shoe heel and that of tray 431.

27 Base 522 of sawing fixture 520 has protruding upwardly from a flat upper surface
28 523 thereof a relatively thick, semi-elliptical ring-shaped table 524 which has a flat upper

1 surface 525 parallel to upper surface 523 of the base, and a vertically disposed semi-elliptically
2 shaped anterior wall surface 526 which is parallel to and recessed radially inwardly of semi-
3 elliptically curved anterior wall surface 527 of the base, thus forming at a junction therewithin
4 a similarly curved, thin base flange wall 528 which protrudes radially outwardly from the table.

5
6 Table 524 of sawing fixture 520 has a flat, vertical posterior transverse end face
7 529 which coincides with the rear wall surface 530 of base 522 and a minor axis of the elliptical
8 plan view thereof. Also, table 524 has protruding vertically downwardly from upper surface 525
9 of the table to upper surface 523 of base 522 a deeply relieved cut-out 531 which has the
10 shape of a semi-elliptical cylinder, the vertically disposed surface of which is parallel to and
11 spaced radially inwardly of outer surface 532 of the table. A lower portion of cut-out 531 is
12 bordered by a thin, short rectangular-shaped end wall 533 which has an upper edge wall 534
13 located between and parallel to upper wall surface 525 of table 524, and upper surface 523 of
14 base 522.

15 Referring still to Figure 42, it may be seen that upper surface 525 of table 524 has
16 formed therein a generally radially disposed horizontal saw groove 535 which penetrates inner
17 vertical wall surface 536 and outer vertical wall surface 532 of the table. Saw groove 535 is
18 located approximately midway between rear transverse wall 529 and anterior vertex 538 of
19 table 524, and preferably has a curved, U-shaped transverse section. Sawing fixture 520 also
20 includes a dental model retainer post 539 which protrudes perpendicularly upwards from upper
21 surface 525 of table 524, on a posterior side of groove 535. Retainer post 539 is preferably
22 located near inner vertical wall surface 536 of table 524 rearward of saw groove 535, and may
23 have a square or other suitable cross-sectional shape.

24 Sawing fixture 520 also includes a thin, vertically disposed arcuately curved dental
25 model retainer flange plate 541 which protrudes perpendicularly upwards from upper surface
26 525 of table 524. Flange plate 541 protrudes arcuately forward from posterior transverse end
27 face 529 of fixture 520, to a location rearward of anterior vertex 538 of table 524. Also, flange
28 plate 541 has an outer arcuately curved wall surface 543 which is coextensive with outer wall

1 surface 532 of table 524, and an inner curved side surface 545 which is parallel to outer wall
2 surface 543, and a horizontally disposed, arcuately curved upper wall surface 546. Groove 535
3 penetrates flange plate 541, and inner wall surface 545 of the flange plate preferably has
4 formed therein alternating vertically disposed ribs and grooves 547, 548, respectively, which
5 are shaped complementary to ribs and grooves formed in a dental model cast by ribs and
6 grooves 449 and 450 of tray 431.

7 Figure 43 illustrates the manner of using full-arch sawing fixture 520. As shown
8 in Figure 43, a full-arch, upper or lower dental model cast JF is placed downwardly on upper
9 surface 525 of fixture table 524, with the lingual and labial sides of the model adjacent to
10 retainer post 539 and retainer flange plate 541, respectively, with a selected portion of the cast
11 corresponding to a first side of an intended die segment positioned above saw groove 535,
12 whereupon a first of a pair of severing saw cuts is made vertically through the dental model
13 cast. The two parts of the dental model cast which have been severed from one another are
14 then withdrawn vertically upwards from table 524, moved circumferentially with respect to saw
15 groove 535 to position a second side of the intended die segment above the saw groove, and
16 moved downwardly onto upper surface 525 of the table, between retainer post 539 and retainer
17 flange plate 541, whereupon a second of a pair of saw cuts required to sever a die segment
18 from adjacent portions of the dental model cast is made. In this way, any number of die
19 segments are conveniently severable from dental model cast JF, help to using sawing fixture
20 520.

21 It should be noted that interlocking action of ribs 547 and grooves 548 in inner
22 surface 545 of retainer flange plate 541 with complementary shaped grooves and ribs on the
23 base of dental model cast JF help to secure the cast in place on table 524 of sawing fixture 520
24 as severing saw cuts are made through the cast. Also, it should be noted that the novel
25 asymmetric geometry of full-arch sawing fixture 520 enables any part of a full-arch dental model
26 cast JF to be positioned for segmenting above sawing groove 535, by positioning the dental
27 model in a forward direction with the anterior portion of the cast facing in the same direction as
28

1 vertex 538 of table 524 as shown in solid lines in Figure 43, or in a revers facing direction as
2 indicated by phantom lines in Figure 43.

3 Figures 44-49 illustrate a drilling alignment fixture 550 for full-arch dental model
4 casts according to the present invention. As shown in Figures 44-49, full-arch drilling alignment
5 fixture 550 has a semi-elliptical plan-view shape and includes a semi-elliptically shaped base
6 plate 551 that has a flat bottom surface 552 and a flat upper surface 553 which is parallel to
7 the lower surface. Base plate 551 of drilling alignment fixture 550 has protruding upwardly from
8 flat upper surface 553 thereof a semi-elliptically shaped curved peripheral flange wall 554 which
9 has a vertically disposed outer wall surface 555 coextensive with the outer perimeter wall
10 surface of the fixture, and an inner wall surface 556 which is parallel to the outer wall surface
11 and spaced radially inwardly thereof. Peripheral flange wall 554 has a flat upper surface 557
12 and includes an arcuately curved anterior portion 558 and a straight, transversely disposed
13 posterior end portion 559 which coincides with a minor axis of the semi-elliptically shaped base.
14 Posterior end portion 559 of peripheral flange wall 554 has formed therein a centrally located,
15 rectangularly-shaped notch 560 which protrudes downwardly from upper surface 557 of the
16 flange wall, the notch terminating at upper surface 553 of base plate 551 of fixture 550. Notch
17 560 provides a clearance for a hinge coupler arm bracket 474 which protrudes rearwardly from
18 a full-arch tray 431.

19 As shown in Figures 44, 45 and 48, base plate 551 of full-arch drilling alignment
20 fixture 550 has through its thickness dimension an elongated aperture 561 which has in plan
21 view the shape of a thin, semi-elliptically shaped sector or band which has an outer vertical wall
22 surface 562 which is parallel to and spaced radially inwardly of outer semi-elliptically curved
23 wall surface 555 of the fixture, and an inner vertical wall surface 563 which is parallel to and
24 spaced radially inwardly of the outer wall surface of the aperture. Semi-elliptical sector-shaped
25 aperture 561 through base plate 551 of drilling alignment fixture 550 serves as a guide track
26 for an elliptically orbitally adjustable drill guide bushing 564, as will now be described.

27 Referring to Figures 44-48, it may be seen that full-arch drilling alignment fixture
28 includes a thin, flat index arm 565 which has a generally longitudinally elongated rectangular

1 plan view shape, and a symmetrically pointed end 566 which protrudes radially outwardly of
2 curved outer perimeter wall surface 555 of the fixture. Index arm 565 is pivotably mounted
3 parallel to lower wall surface 567 of drilling alignment fixture base plate 551 by means of a
4 screw 568 which has a shank 569 threaded into a bore 570 through the base, at a location near
5 a focus of the semi-elliptically shaped base plate. Shank 569 is disposed vertically through a
6 longitudinally elongated, rectangularly shaped aperture slot 571 provided through the thickness
7 dimension of index arm 565. Slot 571 is located on a longitudinal center line of index arm 565,
8 spaced inwardly of a rear transverse edge wall 572 of the index arm. Index arm 565 is retained
9 parallel to and pivotably movable with respect to lower surface 567 of drilling fixture base plate
10 551 by a washer 573 positioned on shank 569 of screw 568, below the slotted head 574 of the
11 screw.

12 Referring to Figures 44, 45, and 48, it may be seen that drill guide bushing 564
13 has a generally cylindrical shape including a lower cylindrical portion 575 which is fastened
14 within a bore 576 provided through index arm 565, radially inwardly from pointed end 566 of
15 the index arm. Drill bit guide bushing 564 also has an annular ring-shaped flange 577 which
16 protrudes radially outwardly from cylindrical body 578 of the bushing, at a longitudinal location
17 between lower end wall 579 and upper end wall 580 of the bushing. Flange 577 has a lower
18 face which is slidable on upper surface 553 of drilling alignment fixture 550. Thus constructed,
19 index arm 565 is pivotable about the axis of screw 568 to pointed end 566 of the index arm in
20 vertical alignment with any selected circumferential location around the periphery of fixture base
21 plate 551. Referring to Figure 46, it may be seen that index arm 565 is optionally and
22 preferably fitted with a pointer index pin or gnomon 583 which protrudes perpendicularly
23 upwards from index arm 565, near tip 566 thereof.

24 As shown in Figure 45, upstanding peripheral flange wall 554 of full-arch drilling
25 alignment fixture 550 forms with base plate 551 a semi-elliptically shaped cylindrical cavity 584
26 which is of the proper size and shape to vertically insertably receive in a conformal fit the lower
27 ring-shaped peripheral wall 441L which protrudes downwardly from centrally located abutment
28 flange 455 of a full-arch tray 431.

Figure 49 illustrates the manner of using full-arch drilling alignment fixture 550. As shown in Figure 49, a full-arch tray 431 containing a full-arch cast JF from which one or more die segments U have been severed from remaining portions of the cast inserted downwardly into cavity 584 of drilling alignment fixture 550, the bottom surface 434 of the tray resting on upper surface 553 of the drilling alignment fixture base plate. Then, index arm 565 is grasped and pivoted orbitally about the axis of pivot screw shank 569 to position tip 566 and gnomon 583 of the index arm in circumferential alignment with a die segment U which is to have a pin bore drilled into the base thereof for receiving a manipulating pin. Fixture 550 and tray 530 are then inverted, and a drill bit or dental burr B is inserted upwardly into bore 590 of drill bit guide bushing 564, into contact with lower surface N of a die segment U. Drill bit B is then rotated by an electric drill to form a blind pin bore P which protrudes inwardly into die segment U from its lower surface. In an alternate method of aligning index arm 565 for drilling a pin bore into a die segment, the die segment is removed from tray 531, and index arm 565 is orbited to a position in which drill bit guide bushing 564 is visually centered below a segment of tray aperture 469 exposed by removal of the die segment. The die segment is then re-inserted into the tray cavity, fixture 550 containing tray 531 is inverted, and a pin bore drilled in the base of the die segment in the manner described above.

Figure 50 illustrates a heavy-duty, 3-D articulator mechanism 600 of a type used in dental laboratories and clinics, and a prior art method of attaching a pair of full-arch dental model casts JF to the articulator mechanism. The 3-D articulator is used for checking proper occlusions of the biting contact areas of dental prostheses fabricated in the laboratory and which are to be used for reconstruction or replacement of one or more defective or missing teeth modeled by the casts.

As shown in Figure 50, a typical prior art method of attaching a pair of full-arch lower and upper dental model casts JFA, JFB to lower arm 601 and upper arm 602 of articulator 600 includes, as shown in Figure 50A, a first step which includes positioning the arches in proper occlusal relationship to one another and temporarily fastening the arches

1 together in that relationship by applying blobs of hot wax U to several contacting regions of the
2 arches, and allowing the wax to cool and harden.

3 A second step in a prior art method of attaching arches JFA, JFB to articulator
4 600 consists of attaching a plastic mounting plate 603 to lower arm 601. As shown in Figures
5 50C, 50D, mounting plate 603 has a flat upper surface 604 which has protruding upwardly
6 therefrom a plurality of intersecting ribs and grooves 604A, 604B arranged in a rectangular grid,
7 and a parallel lower surface 605 into which perpendicularly protrudes a flush-mounted internally
8 threaded bushing 606 and a pair of longitudinally aligned front and rear blind locating bores
9 607F, 607B located on opposite sides of the bushing. Mounting plate 603 is removably
10 attachable to lower arm 601 of articulator 600 by means of a thumbscrew 608 which has a
11 threaded shank 609 that protrudes upwardly through a hole 610 through the lower articulator
12 arm, and which is threadably tightenable into bushing 606 of plate 603. As shown in Figure
13 50B, thumbscrew hole 610 is generally centrally located in lower articulator arm 601, and arm
14 601 has protruding upwards from upper surface 611 thereof a pair of longitudinally aligned front
15 and rear locating pins 612F, 612B which are adapted to be insertably received in blind locating
16 bores 607F, 607B, respectively, of plastic mounting plate 603, thus securing the mounting plate
17 in a pre-determined, irrotatable position on upper surface 611 of the articulator arm, when
18 thumbscrew 608 is tightened into threaded bushing 606.

19 As shown in Figure 50F, a third step in attaching a lower full-arch dental model
20 cast to lower articulator arm 601 consists of applying a relatively thick layer of semi-liquid,
21 viscous liquid die stone to the upper surface of mounting plate 603.

22 A fourth step in fastening a lower full-arch dental model cast JFA to lower
23 articulator arm 601 consists of applying a layer of viscous semi-liquid die stone to a lower
24 surface of a tray T holding the cast. If it is desired to provide a capability for repeatedly
25 removing and replacing the arch from the articulator, a flat disk D made of a magnetized or
26 unmagnetized ferromagnetic material is attached to the lower surface of tray T, as shown in
27 Figure 50F. A pot magnet M is then magnetically attached to an outer surface of magnetic
28 disk D, as shown in Figure 50G. Next, as shown in Figure 50H, a strip of non-adhesive material

1 such as silicone putty SP is secured to the lower surface of tray T, forming an arcuately curved
2 shield or dam which covers pin bores PB provided through the tray for receiving die-
3 manipulating pins, thereby preventing liquid die stone from entering the pin bores. As shown
4 in Figure 50J, plastic mounting plate 603 is attached to lower articulator arm 601. Liquid die
5 stone is then applied in a thick layer over the entire lower surface of tray T, the tray is inverted,
6 pressing liquid die stone thereof into semi-liquid die stone applied to the upper surface of base
7 plate 603, whereupon the two die stone layers cohere and, time is allowed for the cohered die
8 stone layers to harden into a unitary mass, as shown in Figure 50J.

9 The steps described above for attaching a lower full-arch dental model cast JFA
10 to lower articulator arm 601, including a last step depicted in Figure 50K, are repeated to
11 attach upper full-arch dental model cast JFB to upper articulator arm 602, thus making a
12 complete articulated dental model as shown in Figure 50L. By employing magnetic means for
13 attaching trays T to mounting plates 603, as described above, upper and lower arches JFA, JB
14 may be separately removed from 3-D articulator 600 for performing laboratory processing
15 operations on the dental models, and replaced on the articulator in a repeatable occlusal
16 relationship. The dental models are finally removed from the articulator for transporting to the
17 dentist upon completion of laboratory processing of the dental models and prostheses made
18 therefrom. The prior art method and apparatus described above affords no means, absent an
19 expensive duplicate 3-D articulator apparatus in the dentist's office, for positioning a pair of full-
20 arch dental models into a proper occluding relationship for inspection by the dentist and/or
21 patient.

22 Figures 51-54 illustrate the structure and function of a novel full-arch dental model
23 slide receptacle 620 according to the present invention. As will be described in detail following
24 a description of the construction of slide receptacle 620, the slide receptacles enable full-arch
25 dental model casts contained in trays 431 to be replaceably removed from a laboratory
26 articulator, whereupon the models may be returned to the dentist and attached to a lighter duty,
27 less expensive, disposable articulator hinge mechanism 32 to comprise an articulated pair of
28 upper and lower full-arch dental models for viewing by a dentist and his or her patient.

1 As shown in Figures 51 and 53, slide receptacle 620 for use with full-arch dental
2 modeling trays 431 includes a semi-elliptically shaped base plate 621 which has a flat upper
3 surface 622, a flat lower surface 623 parallel to the upper surface, an arcuately curved, vertical
4 anterior wall surface 624, and a straight, transversely disposed posterior vertical wall surface
5 625 which coincides with a minor axis of the semi-elliptically shaped base. As shown in Figure
6 51, base plate 621 has formed in flat lower surface 623 thereof a generally centrally located
7 circular blind bore 626 in which is held a flat circular disk 627. Disk 627 is made of a
8 ferromagnetic material such as iron or nickel, and has a flat lower surface 628 which is co-
9 planar, i.e., flush with lower surface 623 of base plate 621.

10 Referring still to Figure 51, it may be seen that base plate 621 has protruding
11 downwardly from lower surface 623 thereof a plurality of locating or indexing members 629,
12 which are spaced radially outwardly from disk 627, and spaced circumferentially apart from
13 each other. Although the precise number, spacing and shape of indexing members 629 is not
14 critical, the embodiment of slide receptacle 620 shown in Figure 51 includes three radially
15 elongated, generally rectangular plan view ribs 629A, 629B, 629C which have generally
16 triangular cross-sectional shapes modified by curved vertices 630A, 630B, 630C. Ribs 629A,
17 629B, 629C are spaced apart at approximate 120-degree angles and equidistant from the
18 center of disk 627, which is approximately centered on a focus of semi-elliptically shaped base
19 plate 621. Ribs 629 radiate from the center of disk 627, and as shown in Figure 52, protrude
20 perpendicularly downwards from lower surface 623 of base plate 621 and have lower surfaces
21 631 disposed parallel to lower plate surface 623. The function of ribs 629 is described below.

22
23 Referring now to Figures 52 and 53, it may be seen that full-arch slide receptacle
24 620 includes a flange wall 632 which has in plan-view the shape of a semi-elliptical sector that
25 protrudes perpendicularly upwards from upper surface 622 of semi-elliptically shaped base
26 plate 621 of the receptacle. Flange wall 632 has an arcuately curved, outer vertical anterior
27 wall surface 633 which is perpendicularly aligned with arcuately curved anterior wall surface
28 624 of base plate 621, and has at posterior ends thereof a pair of opposed transversely aligned

1 vertical end walls 634A, 634B, which are parallel to and offset a short distance forward from
2 transversely disposed posterior vertical wall surface 625 of the base plate. Arcuately curved
3 anterior flange wall 632 has protruding perpendicularly inwardly from a curved inner wall
4 surface 635 on the flange wall which is parallel to its outer anterior wall surface 633 a radially
5 inwardly turned lip 636 which has a flat upper surface 637. As shown in the figures, lip 636 has
6 the shape of a semi-elliptical sector which has an outer arcuately curved perimeter coextensive
7 with that of curved outer surface 633 of flange wall 632, and an inner perimeter wall 638
8 spaced radially inwardly from inner wall surface 635 of the flange wall. Also, as shown in
9 Figure 53, lip 636 has formed in rear transversely aligned and opposed ends 637A, 637B
10 thereof proximate rear end walls 634A, 634B of flange wall 632 a pair of opposed forward
11 protruding cut-outs or notches 638A, 638B. As is also shown in Figure 53, rear end portions
12 639A, 639B of upstanding flange wall 632 have formed in upper halves thereof transversely
13 inwardly disposed, opposed, arcuately curved club-shaped retainer enlargements 640A, 640B.

14 Semi-elliptically curved flange wall 632, and radially inwardly disposed lip 636
15 which protrudes perpendicularly inwards from the flange wall have inner adjacent vertical and
16 horizontal surfaces 641, 642, respectively, which together with upper surface 622 of receptacle
17 base plate 621 form a semi-elliptically curved channel 643 that is of the proper size and shape
18 to slidably receive semi-elliptically curved lower base surface 434 of a full-arch tray 431. Thus,
19 as shown in Figure 54, to removably install a tray 431 in receptacle 620, base surface 434 of
20 a full-arch tray 431 is placed on upper surface 622 of the receptacle and slid forward on that
21 surface, into channel 643, the upper surface of anterior abutment flange 455 sliding forward
22 on lower surface 644 of lip 636. Tray 431 is slid sufficiently far forward within the channel 643
23 for vertex 455V of anterior abutment flange 455A to abut the vertex 645 of inner vertical surface
24 646 of vertical flange wall 642. Thus positioned, opposed transverse corners of rear abutment
25 flange 455B of tray 432 frictionally wedge between retainer enlargements 640A, 640B,
26 respectively, of flange wall 632, thus retaining tray 431 securely fixed within channel 643 of
27 slide receptacle 620.

1 Figures 54-62 illustrate the manner of using full-arch tray slide receptacle 620.
2 As shown in Figure 54A, 54B, a pair of lower and upper full-arch dental model trays 431A, 431B
3 containing lower and upper dental model casts JFA, JFB, and joined by an articulator hinge
4 mechanism 32 are slidably mounted in a pair of lower and upper slide receptacles 620A, 620B,
5 in the manner described above. Next, as shown in Figures 56A, 56B, a relatively thick layer
6 of viscous semi-liquid die stone is applied to the upper surface 604 of a first, lower arch
7 mounting base plate 603, and the base plate is attached to lower arm 601 of articulator 600 by
8 means of a lower arm thumbscrew 608A. Then, as shown in Figure 57, a pot magnet PM is
9 magnetically attached to disk 627 of lower slide receptacle 620A. Following this step, as shown
10 in Figures 57A and 57B, a relatively thick layer of semi-liquid die stone is applied over pot
11 magnet PM and the lower surface of inverted slide receptacle base plate 621. Lower slide
12 receptacle 620A containing lower full-arch tray 431A and dental model cast JFA is then
13 uprighted, and the semi-liquid die stone layer on the lower surface of the slide receptacle
14 pressed into the semi-liquid die stone layer on the upper surface of lower mounting base plate
15 603. Time is then allowed for the two die stone layers to cohere and harden into a unitary
16 mass.

17 As shown in Figures 58 and 59, the steps described above for attaching a lower
18 full-arch dental model cast JFA contained in tray 431A temporarily slidably mounted in a first
19 lower slide receptacle 620A are repeated to attach a second, upper slide receptacle 620B
20 holding an upper full-arch tray 431B and upper full-arch dental model cast JFB to upper
21 articulator arm 602, thus making a complete articulated dental model as shown in Figure 59.

22
23 By employing magnetic attachment means for mounting lower and upper full-arch
24 slide receptacles 620A, 620B to lower and upper articulator arms 601, 602, the slide
25 receptacles may be separately and repeatedly removed from 3-D articulator 600 to enable
26 various laboratory processing operations required for the manufacture of dental prostheses to
27 be performed on dental model casts JFA, JFB, and the slide receptacles re-attached to the
28 articulator arms in precisely pre-determined positions which provide proper occlusal relationship

1 between the models. Moreover, upon completion of laboratory processing of dental models
2 and prostheses made therefrom using full-arch slide receptacles 620 according to the present
3 invention, slide receptacles 620A, 620B containing lower and upper full-arch trays 431A, 431B
4 and dental models JFA, JFB can be quickly and easily removed from the articulator, as shown
5 in Figure 60, and the trays quickly and easily slidably removed from the slide receptacles, as
6 shown in Figure 61. The trays 431A, 431B containing the full-arch lower and upper dental
7 model casts JFB, JFB can then be returned to the dentist's office where they are readily
8 connectable by a low-cost articulator hinge mechanism 32 to form an articulated full-mouth
9 dental model which has a proper occlusal relationship of sufficient precision, for inspection by
10 the dentist and viewing by his or her patient, as shown in Figure 61.

11 Figures 62-65 illustrate the structure and function of an insert 650 for use with
12 a full-arch modeling tray 431 according to the present invention. As shown in Figures 62-65,
13 insert 650 has a flat, longitudinally elongated, semi-elliptical arch-shaped plan-view base plate
14 651. As shown in Figures 62 and 63, base plate 651 of insert 650 has a generally uniform
15 thickness, and has flat and parallel lower and upper surfaces 652, 653, respectively. Referring
16 to Figure 62, insert 650 may be seen to include a pair of longitudinally elongated, quarter-
17 elliptically-shaped plan view bosses 654L, 654R, which protrude upwardly from upper surface
18 653 of insert base plate 651, the bosses being concentrically located with respect to convex
19 outer, inner and concave inner and left and right rear transverse perimeter wall surfaces 655,
20 656, 657 and 658, respectively, of the base plate. As shown in Figure 62, bosses 654L, 654R
21 of insert 650 have generally vertically disposed outer convex and inner concave side walls 659,
22 660, and front and rear transverse side walls 651, 652, which are inclined towards a vertical,
23 longitudinally disposed mid plane of the boss.

24 Referring now to Figures 63-65, it may be seen that insert 660, constructed as
25 described above, is adapted to be fitted into lower well 463 of tray 431, with bosses 654L, 654R
26 fitting conformally within apertures 469L, 469R through base wall 442 of the tray. Thus
27 positioned, upper surfaces 672L, 672R are substantially flush with upper surface 459 of base
28 wall 442 of tray 431.

1 In a preferred embodiment, tray insert 650 is made of a resilient material, e.g.,
2 an elastomeric polymer such as polyurethane. This choice of materials enables bosses 654L,
3 654R to fit resiliently within apertures 469L, 469R through base wall 442 of tray 431 in a liquid
4 tight seal therewith. Liquid die stone may then be poured into upper wells 439L, 439R of tray
5 431 to form the base of a dental model cast, in the manner shown and described above. After
6 liquid die stone has hardened to form a cast, insert 650 is readily withdrawn from lower wells
7 463L, 463R of tray 431, by grasping an edge of base plate 301 and exerting a downwardly
8 directed parting force relative to the tray, as for example, by grasping an edge of the tray and
9 an edge of the insert base plate between a thumb and forefinger and exerting a pinching force
10 thereon. Following removal of insert 650 from tray 431, a dental prostheses may be fabricated
11 according to the steps shown and described above.

12 Figures 66-72 illustrate modifications of the dental tray and inserts shown in
13 Figures 1-3, 30-32, and 36-38 and described above. The modifications consist of additional
14 structural elements which are effective in forming grooves in the bottom surfaces of dental
15 model casts made using the modified trays and inserts. As is explained in detail below, a
16 groove formed in the base of a dental model cast facilitates drilling bores into the base for
17 receiving manipulating pins.

18 Referring first to Figure 66, a modified dental modeling or molding tray 730 for use
19 in forming dental model casts from liquid die stone poured into the tray and into a dental
20 impression of a quadrant portion of a patient's mouth may be seen to be identical in every
21 respect to the quadrant tray 30 depicted in Figure 1-3 and described above, with the following
22 single exception. As shown in Figure 66, break-away base wall panel 761 portion of base wall
23 742 of modified quadrant tray 730 is provided with a straight, longitudinally elongated,
24 rectangular cross-section rib 780 which protrudes upwardly from upper surface 759 of the
25 break-away base panel. As shown in Figure 66, rib 780 is located midway between front and
26 rear longitudinally disposed edge walls 781, 782 of break-away panel 761. As is also shown
27 in Figure 66, left and right edges 783, 784 of rib 780 are preferably spaced short, equal
28 distances inwardly from left and right side 787, 788, a height less than the depth of upper well

1 739 of tray 730, and preferably has a height of about respectively of the break-away panel.
2 Although the exact dimensions of rib 780 are not critical, the rib has 1/4 inch.

3 Figure 64 is a lower plan view of modified quadrant tray 730, in which a break-
4 away panel 780 thereof has been removed after the tray has been used to pour a dental model
5 cast J, the lower surface M of the base of which is visible through an aperture formed in base
6 wall 742 of the tray by removal of the break-away panel. As shown in Figure 64, the lower base
7 surface M of dental model cast base J has protruding inwardly thereof a longitudinally disposed
8 groove Q which was molded into the base by rib 780 of break-away panel 781, and which
9 therefore has a shape complementary to that of rib 780 of break-away panel 761. As is also
10 shown in Figure 64, base M of dental model cast J has been cut by a pair of saw cuts T1, T2
11 to sever an individual die segment U of the type shown in Figure 17, from the cast.

12 Referring still to Figure 64, it may be seen that dental model cast die segment U
13 has installed into lower surface N thereof a manipulating pin 120. The presence of groove Q
14 in the lower surface M of dental model cast J facilitates drilling pin bores at selected locations
15 into the dental model cast, without the requirement for a drilling fixture, in the following manner.
16 Having selected a desired location for a manipulating pin to be installed in a dental model cast
17 J, e.g., approximately midway between opposite transverse sides of a die segment U as shown
18 in Figures 17 and 63, the tip of a drill bit is inserted into groove Q in cast base surface M at the
19 desired lateral location. Since groove Q is located midway between front and rear longitudinal
20 sides of the cast, the drill bit is also located midway between front and rear sides of the cast.
21 Also, since the groove has vertical side walls which preferably taper inwardly to a smaller
22 relative spacing, a drill bit which has a diameter slightly less than the entrance width of the
23 groove will be snugly aligned within the groove when inserted into the groove, whereupon,
24 rotation means such as a motor may be energized to quickly and easily drill one or more pin
25 bores into the base surface M of the dental model cast J, the bores being substantially well
26 centered in the bases off pie segments.

27 Figures 65-67 illustrate a modification 800 of the quadrant modeling tray insert
28 shown in Figures 30-32. Modified quadrant tray insert 800 is identical in structure and function

1 to insert 300 depicted in Figures 30-32, with the following exception. As shown in Figures 65-
2 66, modified insert 300 is provided with a straight, longitudinally elongated, rectangular cross-
3 section rib 880 which protrudes upwardly from upper surface 822 of the insert. When modified
4 insert 800 is installed in a modeling tray 231 of the type shown in Figures 28 and 29, and used
5 to pour a dental model cast in the manner described above, a groove Q is molded into the base
6 of the cast by rib 880. Groove Q is exactly similar to groove Q shown in Figure 64, and affords
7 the same advantages of guiding a drill bit to drill a pin bore as described above.

8 Figures 71 and 72 illustrate a modification 931 of a full-arch dental modeling tray
9 431 shown in Figures 36-38 and described above. Modified full arch tray 931 is substantially
10 similar in structure and function to full arch tray 431, with the following exceptions.

11 As shown in Figure 71, modified full arch dental modeling tray 931 has arcuately
12 curved left and right break-away center panels 961L, 961R which have protruding upwardly
13 from upper surfaces 962L, 962R thereof arcuately curved, longitudinally elongated, generally
14 rectangular cross section ribs 980L, 980R, respectively. As shown in Figure 68, each rib 980L,
15 980R is located midway between anterior front and posterior rear arcuately curved inner wall
16 surfaces 445U, 446U, of upper peripheral ring portion 441 of tray 931. As is also shown in
17 Figure 71, front and rear edges 963, 964 of rib 980 are preferably spaced short equal distances
18 inwardly from front rear transverse sides 965, 966, respectively, of each break-away panel 961.
19 Although the exact dimensions of rib 980 are not critical, the rib has a height less than the
20 depth of upper well 949 of tray 931, and preferably has a height of about 1/4 inch.

21 Figure 72 is a lower plan view of modified full-arch tray 931, in which break-away
22 panels 961L, 961R have been removed after the tray has been used to pour a dental model
23 cast JF, the lower surface MFR of the right-hand base of which is visible through an aperture
24 formed in base wall 942R of the tray by removal of the break-away panel. As shown in Figure
25 71, the lower base surface MFR of right-hand dental model cast JFR has protruding inwardly
26 thereof an arcuately curved, longitudinally disposed groove QFR which was molded into the
27 base by rib 980R of break-away panel 961R, and which therefore has a shape complementary
28 to that of the rib. As shown in Figure 72, base MFR of dental model cast JFR has been cut by

1 a pair of saw cuts T1, T2 to sever an individual die segment U of the type shown in Figure 17,
2 from the cast.

3 Referring still to Figure 72, it may be seen that dental model cast die segment U
4 has installed into lower surface N thereof a manipulating pin 120. Drilling of a bore for
5 insertably receiving pin 120 is facilitated by the presence of groove Q in a manner exactly
6 analogous to that described above in conjunction with a description of modified quadrant tray
7 730.

8 Referring again to Figure 71, it may be seen that modified full-arch tray 931
9 includes, in addition to ribs 980L, 980R, an additional structure modification which may
10 optionally be included in full-arch tray 431 shown in Figures 36-38 and described above. As
11 shown in Figure 71, front and rear inner wall surfaces 945U, 946U of upper peripheral ring 940
12 of tray 931 have formed therein a plurality of vertically disposed ribs 949 which protrude radially
13 inwardly towards a longitudinal center line of upper well 939. Ribs 949 protrude vertically
14 upwardly of base wall 942, and form between each adjacent pair of ribs a vertically disposed
15 notch or groove 950. As shown in Figure 71, ribs and grooves 949, 950, respectively have in
16 elevation view the shape of a narrow vertically disposed upright and inverted triangles, or
17 wedges, respectively. Preferably, as shown in Figure 71, ribs 949 have a width less than that
18 of grooves 980. This arrangement enables sufficient expansion of solidified die stone in the
19 grooves to exert circumferentially outwardly directed forces on inner facing walls of ribs 949,
20 thereby helping to retain die stone segments in tray 931 when the tray is inverted.